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Hydromulch Increases Seedbed Density of Some Western Conifers

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Hydromulch seedbed treatments at the 1,250-pound-per-acre application rate had the highest seedling emergence after 4 weeks. Hydromulch treatments produced better second-year seedbed densities than soil covering for lodgepole pine and Engelmann spruce, but not for ponderosa pine.

Mulches have been used in seedling nurseries as a protective covering for newly sown seeds for many years. Pine needles, cone grindings, straw, sphagnum moss, burlap, sawdust, and netting have all been used to mulch seedbeds at various nurseries *(1, 3, 4).* Tree nurseries have used hydromulch as a seed covering for over 10 years in the Southeastern United States, where it helps to retard washing of seeds and soil during torrential spring rains. Hydromulch gave the best results in a test of 14 different mulching materials at a Michigan nursery *(3).* This material is not widely used in western nurseries because of the potential for impeded seedling emergence and nursery personnel's unfamiliarity with proper application methods.

There are several commercial brands of hydromulch available, but all are basically wood cellulose fibers that are sometimes mixed with a viscous sticking agent. Hydromulch is sold in compressed dry bales and then mixed with water before use. The mulch is applied to the desired area in liquid suspension through high-pressure nozzles. As the water is absorbed by the soil, the wood fibers coalesce into a cohesive mulch over the soil surface.

Nursery managers are generally agreed that seed mulches are beneficial to seedling germination and emergence. Western tree nurseries have traditionally used soil or sand for covering seeds during spring sowing and straw or sawdust mulches during fall sowing.

The purpose of this project was to test hydromulch on western conifer seedlings under western environmental conditions. The project was a joint venture of Mt. Sopris Nursery and the Missoula Equipment Development Center, both of the USDA Forest Service.

Methods

A "Finn Bantam Hydroseeder" was purchased with project funds by Missoula Equipment Development Center. This model has a standard 66-inch wheel base and specially designed attachments to spread the mulch over a standard 4-foot-wide nursery seedbed (fig. 1). Conwed hydromulch was used in these trials and is representative of commercially available mulches. Conwed hydromulch is available in both a "regular" grade and "Conwed 2000," which contains a sticker.

Three conifer species were used in this test to be representative of seedlings produced in the West: ponderosa pine (*Pinus ponderosa),* Engelmann spruce *(Picea engelmannii),* and lodgepole pine *(Pines contorta).*

Five treatments were set up to test the differences between the two kinds of hydromulch, regular and 2000, and between two typical application rates, 1,250 and 2,500 pounds per acre. The treatments were compared to the standard seed covering as a control. These treatments were randomly assigned to full (120 m) seedbeds within a standard five-bed nursery unit, using a full unit for each of the three species.

Two different types of seeders were also used in this trial. A modified Wind River drill seeder is the standard seeder at Mt. Sopris Nursery and sows seeds in an indented band, tamps the seeds into the soil, and then covers the exposed seeds with a strip of sand one row wide. The sand covering was omitted in this study because we hoped the hydromulch covering would replace the costly and tedious one-row sand cover.

A Love-Oyjord seed drill was also used. This machine actually sows seeds at a preset depth and covers the seeds with soil. Therefore, for the Wind River seeder the

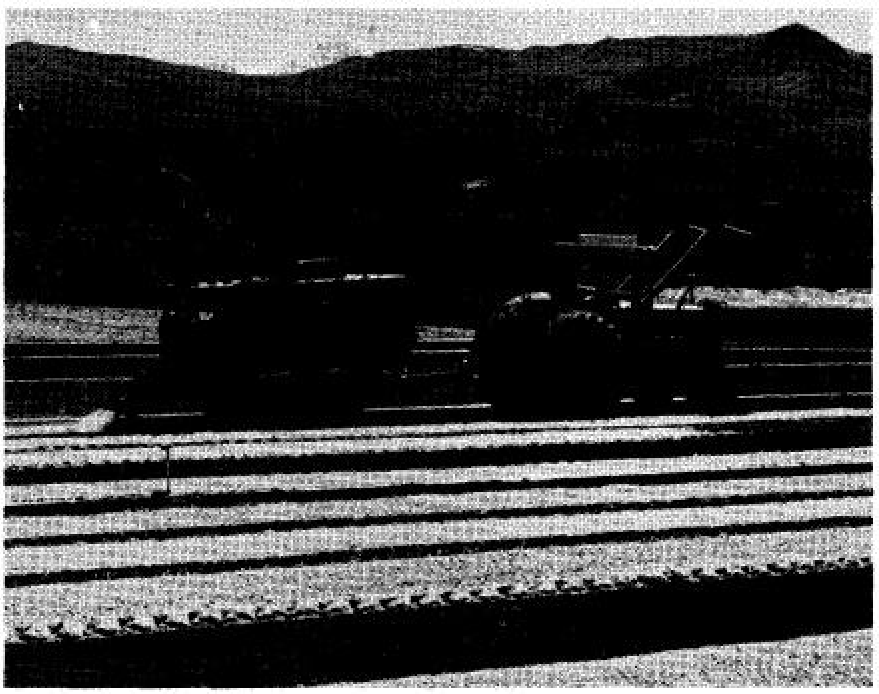

Figure 1—*Application of hydromulch over nursery seedbed immediately after sowing.*

control treatment was sand and for the Love-Oyjord drill it was soil The same seed sources and sowing density were used for each tree species to allow for comparisons of seeders.

The final study design consisted of five treatments, three tree species, and two seeders, using 30 nursery seedbeds. Sampling plots were randomly established within the treatment seedbeds at a sampling intensity of four 6-inch bed-width plots per seedbed. Measurements were taken weekly during early growth and at the end of the first and second growing seasons. Recorded data included seedling emergence rate, seedling size, and stand density and observations on soil moisture and temperature, mulch durability, and bird predation.

Results and Discussion

During the installation of the hydromulch treatments using the Wind River drill, problems with seed covering became obvious. Because the seeds were partially exposed, the pressure of the hydromulch application dislodged many sown seeds from the seed row and left them on top of the soil. Ponderosa pine was the most severely affected because of its larger seed size; the smaller seeded lodgepole pine and Engelmann spruce were least affected. Most of the displaced seeds either did not survive the germination period or were eaten by birds. This portion of the experiment was terminated because of this unforeseen development and the remainder of the study was concentrated on 15 seedbeds sown by the Love-Oyjord seed drill. The remainder of this article deals with these treatments.

Seedling emergence began about 2 weeks after sowing. The emergence pattern for Engelmann spruce is given in figure 2 and is typical for all three seedling species. The soil-covered control beds showed an initial lead in the rate of emergence, but all mulch treatments soon surpassed the control. This pattern of seedling emergence is probably related to the surface soil temperatures in the seedbed. The control bed had the best initial emergence because the dark soil absorbed more solar insolation than the light-colored hydromulch treatments. The hydromulch also provided an insulating layer, which lowered seedbed temperatures and slowed seedling emergence.

The soil control achieved maximum emergence at 3 weeks and then declined in seedling density compared to the mulched beds, which continued to increase in density until 4 weeks after sowing. (fig. 2). Of the hydromulch treat-

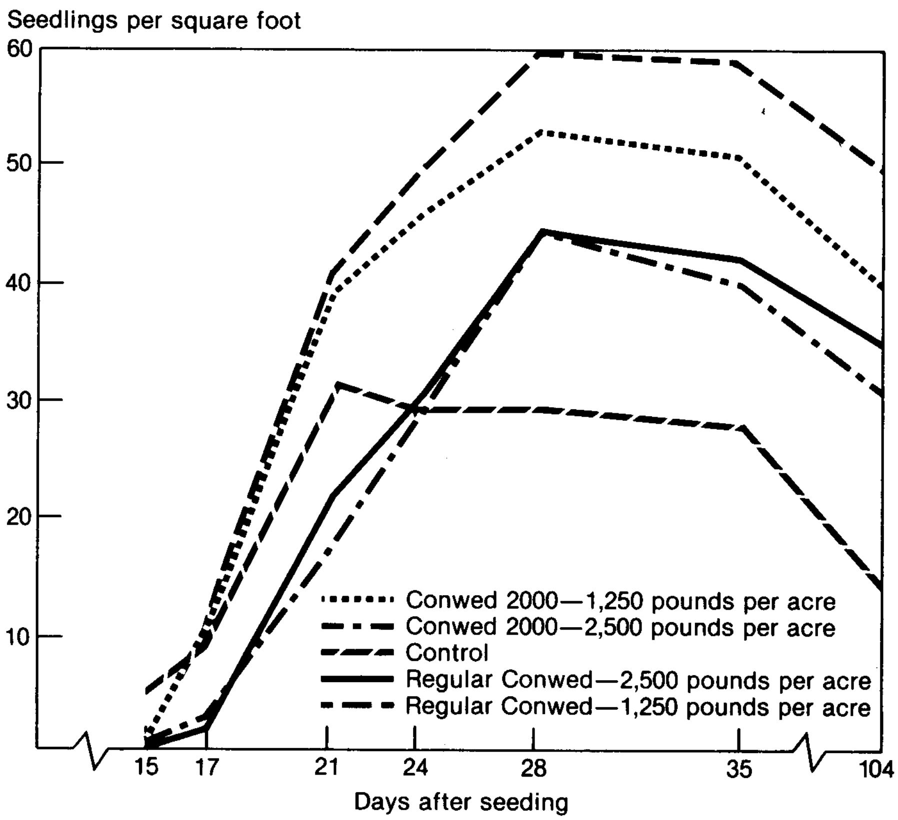

Figure 2—*Emergence rate for Engelmann spruce.*

ments, the 1,250-pound-per-acre treatment had faster emergence rates than the heavier 2,500 pound-per-acre rate; the greater insulating effect of the heavier mulch probably delayed germination and emergence (fig. 2). The two types of hydromulch, regular and Conwed 2000, had remarkably similar results indicating little difference between the products. Maximum seedling emergence for all treatments was reached at 4 weeks after sowing; and after that time, all treatments showed a decline in seedling density (fig. 2). This attrition was probably caused by the natural thinning out of weaker seedlings and is typical of first-year seedbeds at Mt. Sopris Nursery.

Seedling density at the end of the second growing season varied with tree species (fig. 3). The hydromulch treatments produced greater seedbed densities than no-mulch controls for lodgepole pine and Engelmann spruce, but the reverse was true for ponderosa pine (fig. 3). A one-way analysis of variance and Duncan's multiple range test run on these data indicated that the control treatment was significantly different at the 1-percent level from all hydromulch treatments for lodgepole pine and Engelman n spruce For ponderosa pine, the control had significantly higher seedbed density than hydromulch treatments using Conwed 2000, but not than those using Regular Conwed hydromulch. These tests indicate that hydromulch is more effective for small-seeded conifer species than for larger seeded ponderosa pine. Because of the variety of conifer seedlings produced in the West, hydromulch will have to be tested on other species and under the environmental conditions unique to each nursery.

There appears to be little difference between the two types of hydromulch or the two application rates based on the results for all three species (fig. 3). Although there was variation between the treatments for the different species, no one hydromulch treatment was consistently superior. There was no obvious advantage to the hydromulch containing the sticker (Conwed 2000), especially when considering the higher cost. The heavier 2,500-pound-per-acre rate did not prove to have an advantage over the standard 1,250 pound rate. This is contrary to the

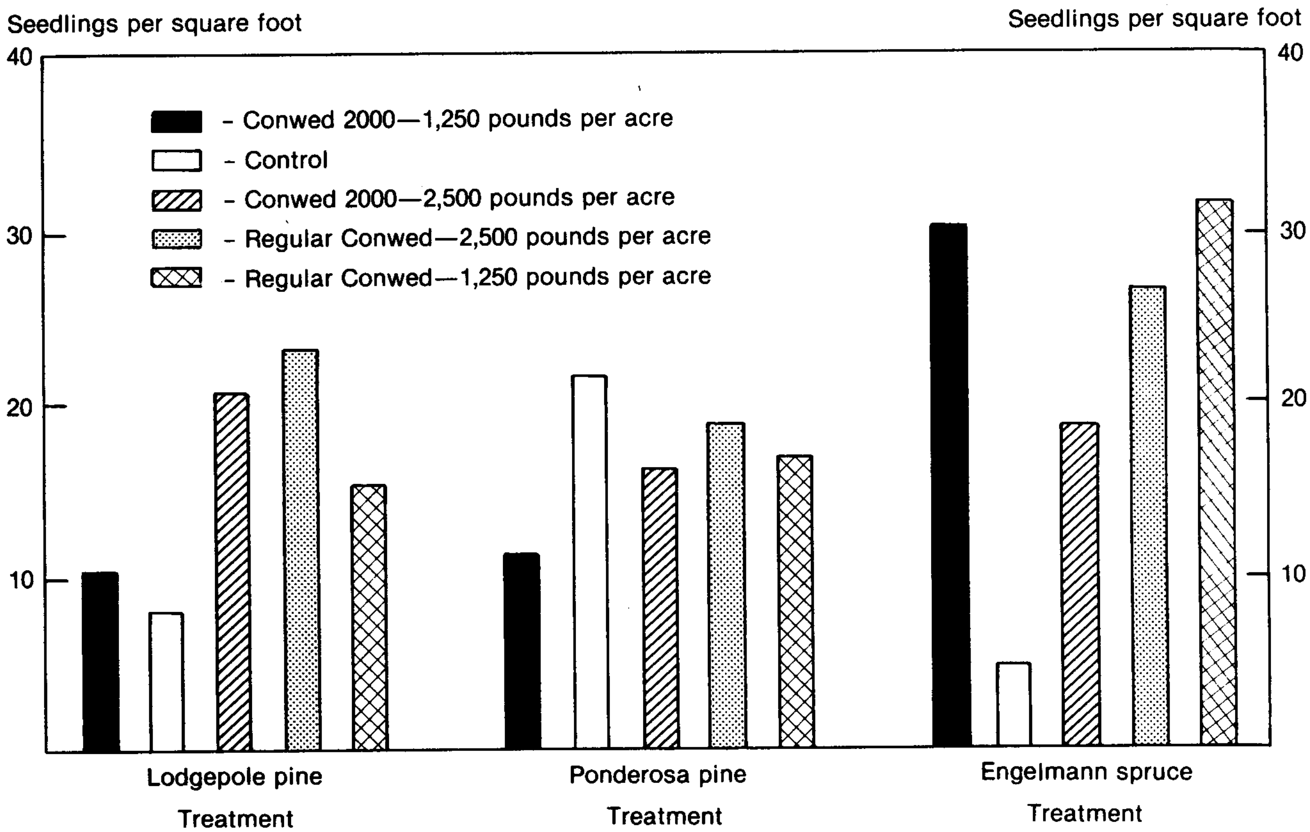

Figure 3—*Seedling density after second year.*

results of Barham (2), who found that a 2,600-pound-per-acre rate was more effective than a 1,300 pound rate for sweetgum on a silty-loam soil. This again emphasizes the need for additional tests on other species of tree seedlings.

Observations on the influence of the hydromulch seed covering on the seedbed environment revealed some interesting facts. Surface soil temperatures were consistently lower and soil moisture higher under the mulch cover. Hydromulch may reduce bird predation of sown seeds. In semi-arid climates, hydromulch may reduce the wicking effect of soluble salts to the soil surface. We did not observe any adverse effects of the hydromulch except some splash erosion onto small seedlings during a heavy rain. This occurrence did not affect seedling growth or restrict seedling emergence in any of the hydromulch treatments.

Conclusions

Hydromulch proved to be an effective seedbed mulch covering when used with a seeding machine that covers the sown seeds. Exposed seeds may be forcibly displaced by the pressure of the hydromulch application.

The hydromulch treatments initially delayed seedling emergence compared to the soil control, but this trend was reversed by the end of the germination period. We observed no inhibition of seedling emergence in any of the hydromulch treatments.

Final seedbed densities of the hydromulch treatments were significantly higher for small-seeded Engelmann spruce and lodgepole pine; ponderosa pine did not benefit from the hydromulch covering.

The standard application rate of 1,250 pounds per acre was as effective as a 2,500-pound rate, and there was no apparent advantage to a hydromulch that includes a sticking agent.

Literature Cited

1. Armson, K. A.; Sadreika, V. Forest tree nursery soil management and related practices. Toronto, ON: Ontario Ministry of Natural Resources, Division of Forests; 1979. 175 p.
2. Barham, R. O. Nursery-grown sweetgum production improved by hydromulching. Tree Plant. Notes. 31: 28-30;1980.
3. Clifford, E. D.; Massello, J. W. Mulching materials for nursery seedbeds. Tree Plant. Notes. 72: 18-22; 1965.
4. Lantz, P. M. Uniformity in seedbed mulching using chemical mulch. Tree Plant. Notes. 20: 8-9; 1969.

Tree Planter's Notes, Vol. 35, No. 3 (1984)

Tree-Planting Machine-- Can You Afford One?

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An effective tree-planting machine must not only plant trees successfully, it must be affordable. To be affordable, a tree-planting machine must plant seedlings at, or less than, the cost of handplanting. Handplanting cost data are readily available. Machine planting costs are not as readily available, so San Dimas engineers devised a method to predict an affordable price for a tree-planting machine.

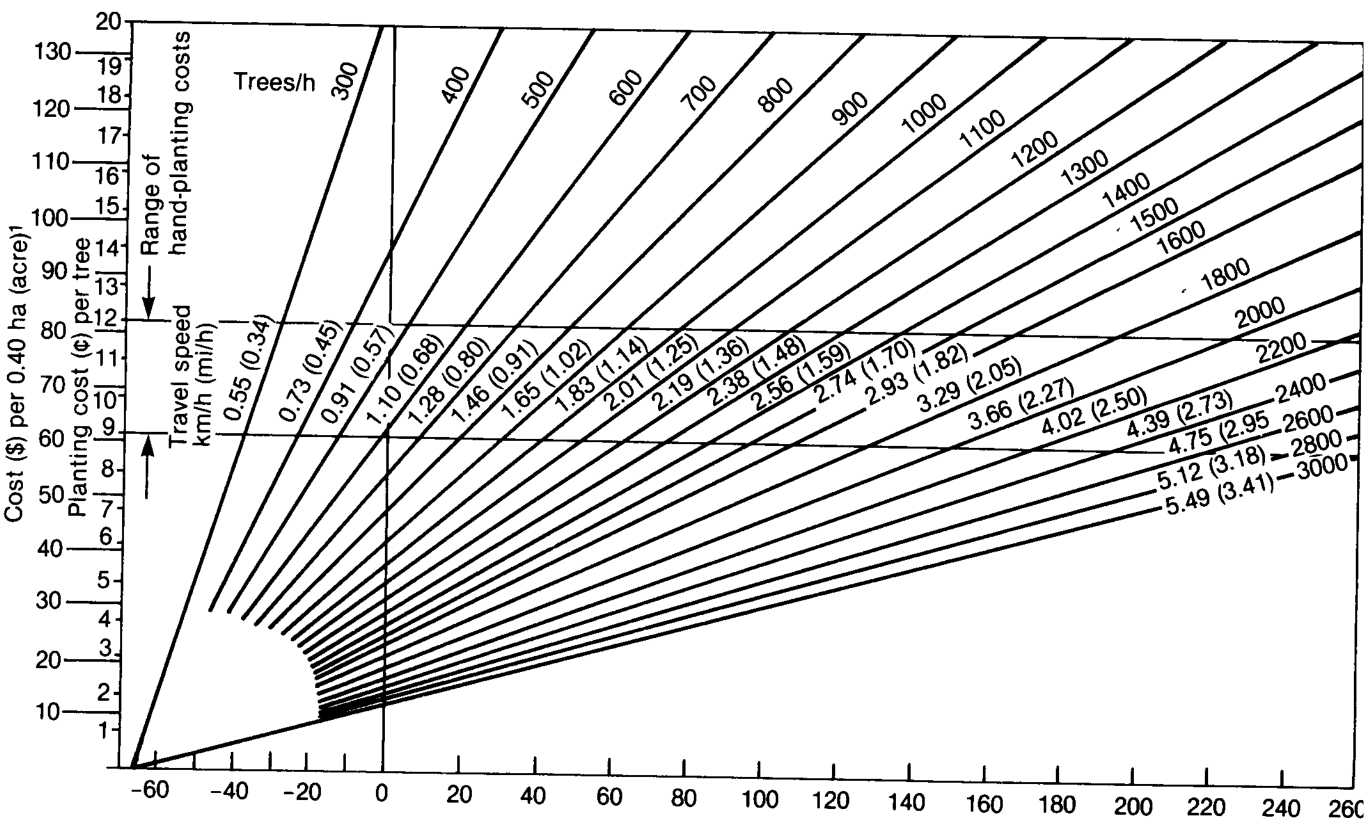
The San Dimas Equipment Development Center was assigned a project for the development of an intermittent tree-planting machine. The first task was to establish performance criteria for a tree-planting machine-one that would meet minimum requirements for quality, dependability, safety, and reliability. Second, the machine would have to be cost-effective; that is, compete economically with handplanting. This would require machine planting costs to be equal to or less than handplanting costs.

The method developed to predict an affordable price for a tree-planting machine is illustrated on the charts in figures 1 and 2. It is based on data and assumptions from the Southeastern United States where such machines are in demand because of tree farms with large areas to be planted and a long planting season. If a different area is considered or these assumptions do not fit, they can be changed and new charts developed.

Assumptions used to develop these charts were:

1. The Southeastern United States is the prime area of concern and the charts are based on its climate, terrain, and labor and equipment rates.
2. While the affordable tree-planting machine can be either an intermittent or continuous-row machine, the intermittent planter is the one under consideration.
3. Site preparation costs are the same loran intermittent tree-planting machine and handplanting.
4. Within the rows, tree seedlings are to be planted 1.8 meters (6 ft) apart.
5. Tree-planting machines have an 85-percent availability; productive equipment time is equal to 85 percent of labor time; and, for a towed planter, the prime mover has an availability of 90 percent.
6. Equipment life is 6,000 hours of operating time over a 10-year period.
7. Overhead plus profit on labor is equal to direct labor cost.
8. Maintenance cost is equal to straight-line machine depreciation cost, without the cost of capital.
9. Machine depreciation cost is calculated by employing the capital recovery factor in conjunction with cost of capital and equipment life.
10. Overhead and profit on equipment are equal to the straight-line depreciation cost, without the cost of capital, plus the maintenance cost; or twice the direct straight-line equipment depreciation cost; or twice the maintenance cost.
11. The cost of capital is 15 percent.
12. The crawler tractor that tows a tree planter ranges in size from 4,500 to 6,300 kilograms (10,000 to 1 5,000 IN and can travel at a speed of approximately 2 kilometers per hour (1.24 mi/h) on cutover areas.
13. The pass-through equipment cost (renter's overhead and profit) equals 0.25 times the equipment cost.
14. The salvage value of equipment after 10 years of use is zero.
15. Tree survival rates for intermittent machine planting are equal to handplanting.
16. Government experiences the same direct overhead and costs as private enterprise.

Using these assumptions, the families of straight lines in figures 1 and 2 can be developed and expressed as a linear equation that



[1]For typical plantings in Southeastern United States: 1.8 x 3.3 m (6 x 10.7 ft) spacing, or 680 trees per 0.40 ha (acre).

Figure 1—*Planting cost at various production rates for a towed tree planter.*

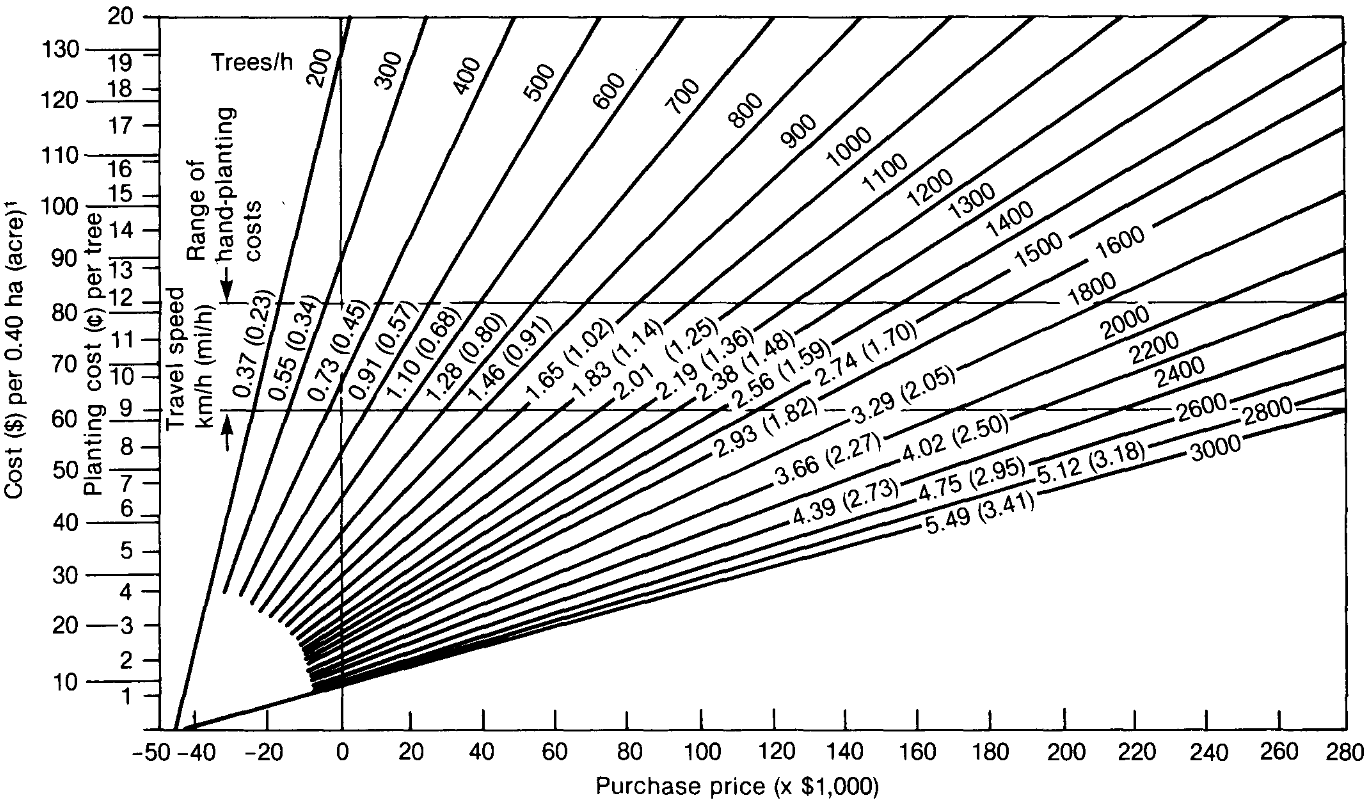
tells how much you can afford to pay for a tree planter:

$X = C_1 + C_2$ *(HPC) (MPR)*

X is the maximum affordable tree planter purchase price in dollars.

C_1 is a negative constant in dollars determined by extending the straight lines to their point of convergence as they intercept the X-axis. By inspecting figure 1 for tow tree planters, C_1 = -$61,500. By inspecting figure 2 for self-propelled tree planters, C_1 = -$46,700.

C_2 is a constant in hours that, when multiplied by *HPC* (handplanting cost in $/tree), gives the additional amount, in dollars, that can be paid for a mechanized tree planter with an increase of one tree per hour in the production rate.



[1]For typical plantings in Southeastern United States: 1.8 x 3.3 m (6 x 10.7 ft) spacing, or 680 trees per 0.40 ha (acre).

Figure 2—*Planting cost at various production rates for a self-propelled planter.*

HPC is the handplanting cost known to exist in the planting location being considered.

MPR is the machine production rate in trees per hour for the unit under consideration.

C_2 has been determined by "plugging in" various sets of values for X, *HPC,* and *MPR* in straight-line relationships in both figures 1 and 2. These solutions for C_2 have resulted in 1,203 hours for a towed planter and 1,202 hours for a self-propelled planter. For example, to determine the maximum economical purchase price, if handplanting in your area costs $0.12 per tree and a towed tree-planting machine being considered for purchase can plant 1,100 trees per hour, the maximum economical purchase price for that planter is $X = C_1 + C_2 (HPC) (MPR)$ = -$67,500 + 1,203 hours ($0.12/ tree) (1,100 trees/hour) = $91,300. Alternatively, you could use figure 1.

Recent (1980) contracts in the Southeastern United States indicate the *HPC* range is from $0.09 to $0.12 per tree. At $0.12 per tree, the maximum that you should be willing to pay for an intermittent tree planter with an *MPR* of 1,100 trees per hour is $91,300 for a towed planter and $112,000 for a self-propelled unit. If we were to assume a two-row machine with an *MPR* of 1,500 trees per hour, the maximum affordable price for an *HPC* of $0.12 per tree is $149,000 for a towed machine and $169,000 for a self-propelled one. Also, from figures 1 and 2, a machine must have a planting rate of at least 540 trees per hour (if we assume a minimum machine cost of $10,000 for a towed unit and $27,000 for a self-propelled unit) to be affordable. At a planting rate of 540 trees per hour, this will only allow 6.7 seconds to plant each tree. At this rate, planting cannot be a stop-and-go operation and specific spot selection for seedling insertion cannot be made. At higher, more desirable (and possibly necessary to make the machine affordable) planting rates, the problems of stop-and-go operation and specific spot selection become more acute.

In conclusion, the most important factor that a designer of a tree planter has control over is the production rate of the machine. A production rate of at least 600 trees per hour must be achieved or an intermittent tree planter will not be economical (affordable). Much higher planting rates than 600 trees per hour are desirable and may be necessary for the machine to, be affordable, depending on the cost of the machine and other circumstances.

Project Record 8124 1203, June 1981, "Tree-Planting Machine-- How Much Can You Afford To Pay For One?", contains more detailed information on this subject. It is available from the San Dimas Equipment Development Center.

Early Cone Collection and Postharvest Treatment Comparisons in a South Carolina Loblolly Pine Seed Orchard

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Placing loblolly pine cones in muslin sacks and air-drying in the shade of orchard trees yielded adequate quantities of high-quality seeds. Cones can be collected as early as August 29 with satisfactory seed yields if postharvest treatments are applied.

Demand for improved loblolly pine (*Pinus taeda* L.) seedlings is placing greater pressures on seed orchard managers to collect and process larger numbers of cones. Mature loblolly pine cones are normally handpicked within a 2-to 3-week period (7). A shortage of labor and equipment during this limited harvesting period may reduce the numbers of cones collected. If cone harvesting could begin several weeks earlier, followed by a satisfactory postharvest treatment, the number of seeds obtained could be greatly increased.

Several studies have indicated that an extended cone harvesting period for loblolly pine is possible if slightly immature cones are stored before kiln drying (2, 3, 4, 5, 8, 9). Effects of postharvest treatments and early cone collection on the degree of cone opening and germinative capacity for Coastal and Piedmont loblolly pine clones from South Carolina were investigated by Astriab and Schoenike (1). Cones stored in shade with moist burlap covers and cones stored in burlap bags and air-dried under the shade of orchard trees proved best of five treatments for Piedmont clones. Additional work was needed with Coastal loblolly pine because of the large variability among clones. The present study was initiated to further examine the effects of early collection and these treatments on seed yield and germinative capacity of Coastal loblolly pine. An analysis of cone specific gravity was made to assess its reliability as an index of cone maturity.

Materials and Methods

Seven clones of loblolly pine were selected from the Coastal seed orchard located at the Fulton B. Creech Seed Orchard Complex, South Carolina State Commission of Forestry, near Sumter, S.C. Twenty-two cones were handpicked from each clone at six weekly intervals beginning on August 22, 1980. At each weekly collection, two cones were randomly selected for specific gravity measurement using water displacement. The remaining 20 cones were divided into two groups of 10 cones each and placed in separate muslin sacks. The sacks were randomly assigned to one of two postharvest treatments, the "artificial shade" treatment and the "orchard" treatment. The artificial shade treatment consisted of placing the sacks on the ground beneath burlap-covered lath and sprinkling them with water about every 3 days. This procedure is very similar to the method currently used with Piedmont loblolly pine clones at the Fulton B. Creech Seed Orchard Complex. The orchard treatment consisted of placing the sacks on the ground at the base of orchard trees. Four weeks after the last cones were picked, postharvest treatments were terminated. All sacks were then placed in a forced-air dry kiln for a period of 5 days at 120° F for cone drying to facilitate seed removal.

After kiln drying, each cone was "bumped" to remove all available seeds. No seeds were forcibly extracted. The degree of each cone's openness was rated by assigning a value from 1 to 5, in which a value of 1 indicated fully closed cones and a value of 5 indicated fully open cones. Seeds were counted and weighed, and then a germination test was conducted. A 50-seed sample from each treatment-date-clone combination was stratified for 3 weeks at 40° F. Germination procedures followed the method described for loblolly pine in "Seeds of Woody Plants of the United States" (7).

A randomized, complete-block, split-plot design was employed with postharvest treatments and clones as whole-plot and collection dates as subplot factors. Analysis of variance was performed for degree of cone openness, average total seed weight per cone, seed number per cone, and germinative capacity. In addition, a completely randomized design was employed to test differences in cone specific gravity among clones and dates. Differences among means for collection dates were tested at the 5-percent probability level using linear contrasts (6).

Results

No significant differences between artificial shade and orchard treatments were detected in degree of cone openness or total weight or number of seeds per cone (table 1). Seeds from cones given the orchard treatment had a small, but significantly higher, germinative capacity.

There was a linear increase in degree of cone openness and total seed weight and number per cone with cone collection date (fig. 1). The shade treatment produced better cone opening than the orchard treatment on all dates except the last, September 26 (fig. 1). terminative capacity increased with cone collection date until September 12, after which germinability decreased. The first cone collection date, August 22, yielded significantly lower seed germinative capacity and total seed weights and numbers per cone than other collection dates. Treatment-date and treatment-clone interactions were not significant for any of the variables examined.

Cone specific gravity was not a reliable index of cone maturity because of large variation among clones. Cone specific gravity was fairly uniform among clones on the first collection date, August 22; but afterwards variation among clones increased with time. There was a linear decrease in cone specific gravity with collection date from 1.05 on August 22 to 0.94 on September 26. Although average cone specific gravity on each collection date was greater than 0.89 (the traditional index of cone maturity), acceptable seed yields of more than 50 seeds per cone were obtained on all collection dates except the first, August 22.

Table 1—*Results of artificial shade and orchard treatments for Coastal loblolly pine*

Cone collection date	Post-harvest treatment	Degree of cone openness	Number of seeds per cone	Total seed weight per cone	Germinative capacity
				g	%
August 22	Artificial shade	4.2	47.3	1.22	10.9
	Orchard	4.0	39.4	0.98	13.7
August 29	Artificial shade	4.6	59.9	1.64	48.6
	Orchard	4.3	65.0	1.68	47.1
September 5	Artificial shade	4.3	67.3	1.87	58.3
	Orchard	4.2	64.7	1.76	56.9
September 12	Artificial shade	4.8	66.9	2.01	72.6
	Orchard	4.3	59.6	1.86	79.1
September 19	Artificial shade	4.7	52.6	1.61	64.6
	Orchard	4.3	56.8	1.60	66.0
September 26	Artificial shade	4.6	52.6	2.14	55.1
	Orchard	4.9	73.0	2.24	60.9
Mean	Artificial shade	4.5	61.0	1.69	51.7[1]
	Orchard	4.4	59.8	1.74	54.0[1]

[1] Significant difference between treatments at the 0.05 probability level.

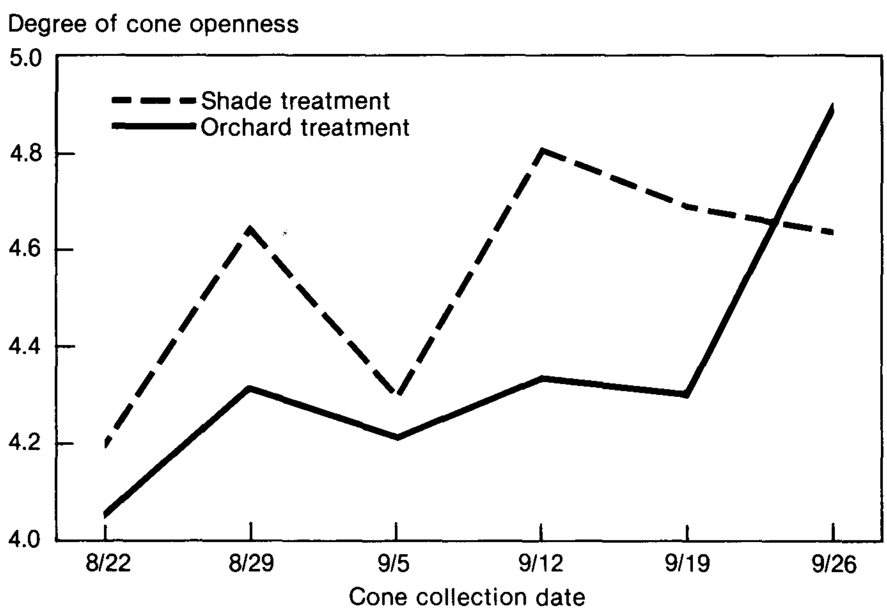

Figure 1—*The relationship between cone collection date and specific gravity.*

Conclusions

The orchard treatment used in this study is recommended for postharvest treatment to artificially ripen loblolly pine cones in South Carolina because: (a) there were no significant differences in degree of cone openness and average total seed weight and number per cone between the orchard and artificial shade treatments; (b) the orchard treatment yielded higher germinative capacities than the artificial shade treatment; and (c) the orchard treatment is a simpler, less expensive procedure. By applying this postharvest cone treatment, the harvesting period could be extended by 5 weeks, thus making commercial seed production cheaper and more efficient and allowing more seeds to be harvested.

Literature Cited

1. Astriab, T. D.; Schoenike, R. E. Early loblolly pine cone collection in a South Carolina seed orchard. In: Proceedings of the 16th southern forest tree improvement conference. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1981: 241-246.
2. Barnett, J. P. Earlier collection dates for southern pine cones. In: Proceedings, southeastern area, nurserymen's conference, western session; 1976 August 17-19; Mobile, AL. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1976: 50-56.
3. Kundt, J. F.; Lantz, C. W. Cone ripening study of loblolly, Virginia and shortleaf pines. 1968. 11 p. Unpublished report located at North Carolina State University Cooperative Tree Improvement Program, Raleigh, NC.
4. Lantz, C. W. Artificial ripening techniques for loblolly pine cones. In: Proceedings of the seed collection workshop; 1979 May 16-18; Macon, GA. Tech. Pub. SA-TP8. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1979: 53-58.
5. McLemore, B. F. Collection date, cone-storage period affect southern pine seed yields, viability. Tree Plant. Notes. 26(1): 24-26; 1974-75.
6. Mendenhall, W. Introduction to linear models and the design and analysis of experiments. Belmont, CA: Wadsworth Publishing Co.; 1968. 265 p.
7. Schopmeyer, C. 5., tech. word. Seeds of woody plants of the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture; 1974: 624-625.
8. Wakeley, P. C. Planting the southern pines. Agric. Monogr.18. Washington, DC: U.S. Department of Agriculture; 1954. 233 p.
9. Waldrip, B. T. Artificial ripening of loblolly pine cones and seeds. In: Proceedings, southeastern nurserymen's conference; 1970 July 27-29; Cadiz, KY. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1970:82-91.
10. Wasser, R. G. Loblolly early cone collection study. In: Proceedings, southern nursery conference, eastern session; 1978 August 7-10; Williamsburg, VA. Tech. Pub. SA-TP6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1978: 22-25.

A Morphological Comparison of Greenhouse-Grown Loblolly Pine Seedlings With Seedlings Grown Outdoors

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Loblolly pine (Pinus taeda *L.) seedlings grown in a greenhouse were found to be taller, more slender, and less branched than those grown outside. These morphological differences apparently were caused by a shift of light wavelengths and protection from disturbance by wind in the greenhouse.*

Growing tree seedlings in an artificial environment such as a greenhouse causes them to be morphologically different from their counterparts grown outdoors. Generally, seedlings grown indoors tend to be taller and more slender than those grown outdoors. The list of factors that may lead to such differences includes: (1) intensity, quality (wavelength), and duration (photoperiod) of light; (2) physical disturbance, mainly wind, to which outdoor-grown seedlings are exposed; (3) relative humidity; and (4) temperature.

A greenhouse, especially when covered with shade cloth to reduce temperature, blocks out radiation. This not only reduces light intensity, but it also shifts the light spectrum to the right-away from ultraviolet and toward far-red (4, 11). Pine seedlings and other intolerant trees generally increase in relative elongation when shaded. If the photoperiod (light duration in a 24-hour cycle) is extended artificially, height growth may be increased even more. Daylength may not only affect height growth, but also radial growth and the dormancy period (7). The type of artificial lighting used in a greenhouse may also significantly affect seedling growth.

Plants growing in a greenhouse or growth chamber are not disturbed by wind, which has been shown to have a significant effect on the growth habit of many plants. Many plants respond to mechanical stimulation by elongating more slowly and increasing their radial growth. Wind may be considered a stress, and plants respond to it by growing stockier and sturdier (S). Mechanical disturbance has also been shown to induce dormancy in sweetgum *(Liquidambar styraciflua* L.) trees (10).

Changes in relative humidity and temperature can affect photosynthetic rate, growth, and other physiological processes in the plant. Hammer and others (4) implicated a higher relative humidity and a lack of temperature extremes as causes of "greenhouse lushness." Furthermore, while seedlings of many species in a greenhouse or growth-chamber may be induced to enter dormancy by shortening the photoperiod, most species require exposure to near-freezing temperatures in order to break dormancy and resume normal growth (8). Mexal and others (9) suggest that containerized seedlings outplanted in the fall should be exposed to low temperatures before lifting in order to induce cold-hardening.

Materials and Methods

As part of a study on chilling requirements for breaking dormancy in loblolly pine, two seed sources were grown both outside and in a greenhouse. One source of seeds was southeastern Virginia; the other was southeastern Georgia. Seeds were sown in May 1983. In order to avoid washing of containers by heavy rain, seedlings to be grown outside were started in the greenhouse and moved outdoors approximately 2 weeks after sowing.

Seedlings at both locations (inside and outside) were grown in 164-cubic-centimeter Leach-cells (Ray Leach "Cone-tainer" Nursery, Canby, Oreg.). A 2:2:1 mixture of peat moss, vermiculite, and perlite with 3.5 kilograms per cubic meter of 18-7-10 Sierrablen time-release fertilizer (Sierra Chemical Co., Milpitas, Calif.) added was used as a growth medium. In the greenhouse, the photoperiod was extended to 16 hours with artificial lighting (300-watt incandescent lamps). Seedlings outside grew under natural daylengths (approximately 14 hours from May to August). The greenhouse was covered with shade cloth to reduce temperatures. Temperatures inside the greenhouse were further reduced by means of air pulled across wet cooling pads. Light intensity in the greenhouse at midday was approximately 350 $\mu E\ s^{-1}\ m^{-2}$ with full sunlight, compared to 1,550 $\mu E\ s^{-1}\ m^{-2}$ just outside the greenhouse.

Twelve weeks after sowing, 100 greenhouse- and 100 outdoor-grown seedlings from each seed source were measured for epicotyl length (that portion of the stem above the cotyledons), ground-level diameter, and number of lateral branches. Epicotyl length was measured rather than total height because much of the hypocotyl of the outdoor-grown seedlings (that portion of the stem below the cotyledons) was developed in the greenhouse.

Results and Discussion

Morphological differences between seedlings grown outside and in the greenhouse were striking (figs. 1 and 2). Seedlings grown inside were taller, more slender, and less branched than those grown outside. Differences in height, diameter, height-diameter ratio, and the number of lateral branches were all very highly significant (table 1). Seedlings in the greenhouse probably grew taller and more spindly through a combination of differences in light quality and quantity and a lack of mechanical stimulation. At present, one can only speculate on the rel-

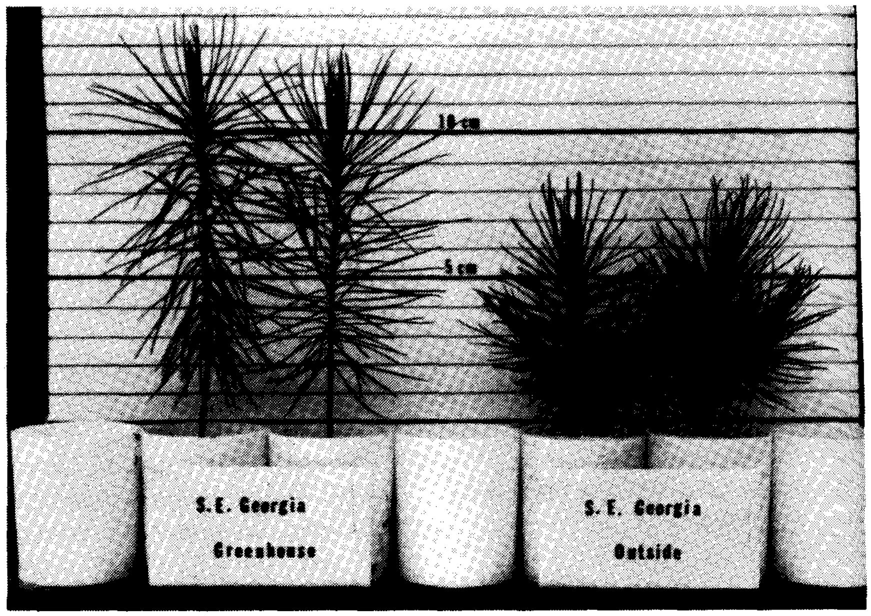

Figure 1—*Comparison of morphology of 12-week-old southeastern Georgia seedlings grown in a greenhouse and outside.*

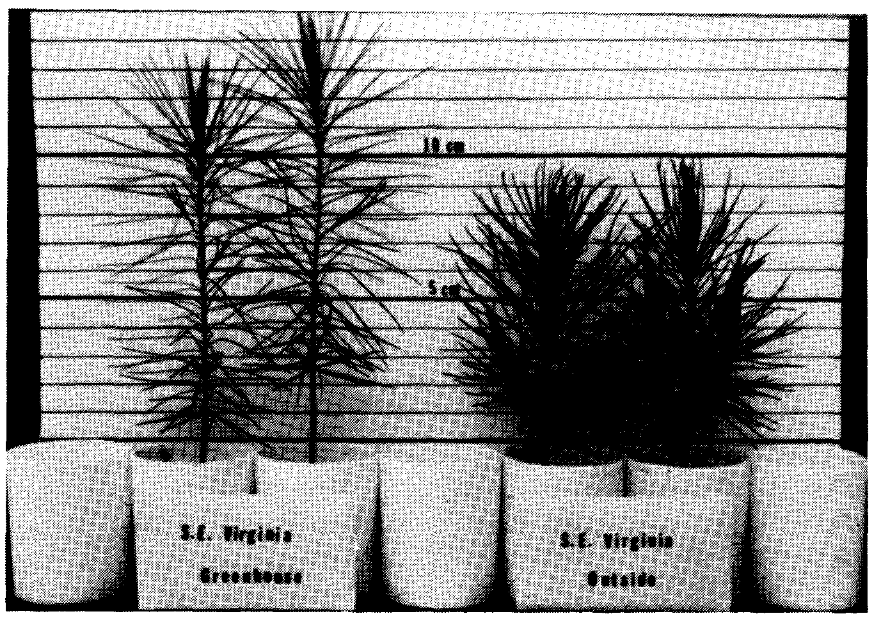

Figure 2—*Comparison of morphology of 12-week-old southeastern Virginia seedlings grown in a greenhouse and outside.*

Table 1—*Morphological characteristics of seedlings from two seed sources grown outside and in a greenhouse (12 weeks after sowing)*[1]

Seed source	Stem length	Stem diameter	Length to diameter ratio	Lateral branches
	mm	*mm*	*mm/mm*	*No./tree*
Southeastern Georgia				
Inside	69.8 ± 2.0	1.42 ± 0.02	49.0 ± 1.2	0.23 ± 0.05
Outside	37.4 ± 0.9	1.78 ± 0.02	21.0 ± 0.5	2.62 ± 0.11
Southeastern Virginia				
Inside	73.7 ± 1.8	1.48 ± 0.02	49.7 ± 1.1	0.11 ± 0.04
Outside	41.7 ± 1.2	1.85 ± 0.02	22.5 ± 0.6	2.80 ± 0.11

[1]Each number represents the mean of 100 seedlings and is followed by its standard error. All differences between locations are significant at $P < 0.0001$.

ative importance of these factors.

Light intensity may not have been as critical as light quality. Because of their leaf arrangement and leaf anatomy, loblolly pine seedlings with foliage composed mainly of juvenile needles are more adapted to lower light intensities than are 1-to 2-year-old seedlings (7). Photoperiod was probably not an important factor, either. The photoperiod in the greenhouse (16 hours) was not very different from that outside (approximately 14 hours from sunrise to sunset plus twilight).

The quality of the supplemental light, however, may have played an important role in seedling morphogenesis. Incandescent lamps emit strongly in the far-red part of the spectrum, while fluorescent lamps emit strongly in the red. Plants receiving far-red light grow significantly taller than plants receiving red light, which inhibits elongation (2). The red-far-red effect depends strongly upon the type of light plants receive last -- just before the onset of the dark period. Furthermore, the intensity of the light does not have to be great to cause an effect. Many kinds of plants elongate markedly when irradiated briefly with far-red light following each daily period of high-intensity light (2). Loblolly pine, among other tree species, shows significant increases in growth with incandescent as opposed to fluorescent supplemental lighting (3). The fact that the greenhouse-grown seedlings in this study received exclusively incandescent light for an hour before each dark period could, in part, explain the taller plants produced.

With the seedlings grown outdoors, the effects of light quality may have been coupled with a response to mechanical stimulation by wind. Specifically, wind stress may have triggered hormone reactions that induced more radial growth and lateral branching and less elongation. Telewski and Jaffe (72) fund that loblolly pine seedlings receiving daily mechanical disturbance in a greenhouse (brushing with a wooden rod) were significantly shorter than undisturbed control plants growing alongside them. Kellogg and Steucek (6) observed that shaking young Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) trees growing in a greenhouse had a marked influence on leader growth. They suggested, however, that when comparing greenhouse-grown trees with trees grown outside, temperature and humidity may be major factors contributing to the growth of outside-grown trees rather than a response only to mechanical disturbance by wind. Trees grown outside in this study were exposed to higher temperatures and lower humidities than those in the greenhouse. This placed outside-grown trees under greater water stress. Thus, at least a portion of the growth differences recorded may be attributable to temperature, humidity, and plant water status.

Currently, producers of containerized loblolly pine seedlings in the South usually grow the trees in a greenhouse or lath-house. There may be instances where they should consider simply growing the seedlings outdoors in full sunlight in order to produce higher quality trees and reduce costs, such as when seedlings are grown during the summer to be outplanted in the fall. A possible concern about this approach would be washing of containers by heavy rains. The authors, however, found that, once the growth medium was initially settled, washing did not occur, even with very heavy rains. Finally, growers who conduct progeny tests in a greenhouse should be aware that morphology attained in these tests is likely to be quite different from that attained outdoors. Different families may even respond differently to greenhouse conditions versus outside conditions.

Literature Cited

1. Bormann, F. H. Ecological implications of changes in the photosynthetic response of *Pinus taeda* seedlings during ontogeny. Ecol. 37: 70-75; 1956.
2. Downs, R. J. Photocontrol of growth and dormancy in woody plants. In: Kozlowski, T. T., ed. Tree growth. New York: Ronald Press; 1962: 133-148.
3. Downs, R. J.; Piringer, A. A. Effects of photoperiod and kind of supplemental light on vegetative growth of pines. For. Sci. 4: 185-195; 1958.
4. Hammer, P. A.; Mitchell, C. A.; Weiler, T. C. Height control in greenhouse chrysanthemum by mechanical stress. Hortsci. 9: 474-475; 1974.
5. Jaffe, M. J. The sense of touch in plants. In: Salisbury, F. B.; Ross, C. W., eds. Plant physiology. 2d ed. Belmont, CA: Wadsworth Publishing Co., Inc.; 1978: 286.
6. Kellogg, R. M.; Steucek, G. L. Motion-induced growth effects in Douglas-fir. Can. J. For. Res. 7: 94-99; 1977.
7. Kramer, P. J.; Kozlowski, T. T. Physiology of woody plants. New York; Academic Press; 1979. 811 p.
8. Lavender, D. P. Environment and shoot growth of woody plants. Res. Pap. 45. Corvallis, OR: Oregon State University, Forest Research Laboratory; 1981. 47 p.
9. Mexal, J. G.; Timmis, R.; Morris, W. G. Cold-hardiness of containerized loblolly pine seedlings. South. J. Appl. For. 3: 15-19; 1979.
10. Neel, P.L.; Harris, R.W. Motion-induced inhibition of elongation and induction of dormancy in *Liquidambar. S*ci. 173: 58-59; 1971.
11. Salisbury, F. B.; Ross, C. W. Plant physiology. 2d ed. Belmont, CA: Wadsworth Publishing Co., Inc.; 1978. 422 p.
12. Telewski, F. W.; Jaffe, M. J. Thigmomorphogenesis: changes in the morphology and chemical composition induced by mechanical perturbation in 6-month-old *Pinus taeda* seedlings. Can. J. For. Res. 11: 380-387; 1981.

Production Costs in Southern Bareroot Nurseries

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Seedling production costs are reported for 10 southern forest nurseries. The major cost components include administrative costs; seed costs; and cost of lifting, culling, and packing.

Southern forest nurseries produce a total of more than 1.3 billion seedlings annually. Of this number, loblolly pine (*Pinus taeda* L.) accounts for approximately 1 billion. In 1983, the selling price for 1,000 bareroot loblolly pine seedlings ranged from $14 to $40. (1). However, outside a few nursery-specific cases (2, 3, 4), there is little published information on the cost of bareroot seedling production in the South. For this reason, in the spring of 1983, a production cost questionnaire was sent to a selected number of bareroot nurseries operating in the South. Data from the questionnaire are reported in this paper. These data are presented to determine the relative cost of inputs for southern bareroot nurseries, to encourage cost analysis by nursery managers, and to provide references for determining future cost trends.

Methods

A production cost questionnaire was mailed to 35 of approximately 70 public and private forest nurseries in the South. The selection of nurseries was based on two criteria-that the nursery's soil texture was more than 75-percent sand and that private nurseries have a company policy of releasing cost production data. This sampling frame resulted in a slight bias toward nurseries established after 1970 when a higher sand content for nursery soils became the norm.

Results

Fourteen of the 35 nurseries responded to the questionnaire. However, only nine questionnaires reported individual cost components, and one provided seed and total cost per thousand. Of the 10 reporting cost figures, 6 were from private nurseries and 4 were from public nurseries.

Table 1 shows the percentage each component cost is of the nursery's total cost per thousand. Average seedling cost per thousand reported ranged from a low of $10.95 to a high of $26.61. The blank responses for particular cost components are difficult to interpret. In some cases, they mean that the nursery does not perform that particular task; and in others, the nursery was not able to compute a separate cost for the task. This would help explain the frequent use of the "other cost" categories.

The average reported seedling cost per thousand was $17.82. The numbers in the "average" column in table 1 are the average of the actual costs reported on the questionnaires. This number is the average of the entries in the corresponding row. Since the number of entries varies for each row, the sum of the row averages does not equal the average seedling cost of $17.82. These row averages could be used to estimate where a particular nursery operation stands in relationship to the other nurseries reporting this component cost.

Examination of the percentages reported in table 1 reveals that administrative costs are the most significant category, followed by lifting, culling, and packing costs. Since these costs range from 7 to 37 percent of total cost, the opportunity for cost savings in the lifting, culling and packing operation in some nurseries is large. However, seed cost is the individual component cost that, is the highest percentage of total cost. Depending on whether unimproved or improved seeds are used, the percentage of total cost varies from less than 5 to almost 30. As the use of improved seeds increases, the seed cost will become a larger percentage of total production cost for most nurseries. For example, assuming that seeds cost $100 for 12,000 pure, live seeds and that 9,000 plantable seedlings would be produced from these seeds, seed cost per 1,000 plantable seedlings would be $11.11.

Table 1—*Component cost as a percentage of total cost per 1,000 loblolly pine seedlings produced on 10 bareroot forest nurseries in the South*

Component	Nursery										Average[1]
	1	2	3	4	5	6	7	8	9	10	
	Production information										
Major species produced	Lob.[2]	Lob.	Lob.	Lob.	Lob.	Lob.	Lob.	Lob.	Lob.	Lob.	
Production (millions)	12	25	18.7	20	20.4	23	23.2	40	2	16	
Planting density/ft^2	26	35	31.1	28	27.5	24	28	30	25	26	
Crop rotation (pine/cover)	2/2	1/2	1/1	1/1	1/1	1/1	1/1	2/2	2/1	2/2	
	Cost information *% of total seedling cost per 1,000*										*Dollars/1,000*
Seed	21.30	10.95	4.84	11.32	16.30	23.38	11.52	8.00	18.72	29.73	2.94
Stratification	—[3]	.09	.19	.12	—	.27	.08	.03	.24	—	.02
Fertilizer	.66	.34	.58	2.13	1.36	—	.28	.50	.34	—	.13
Seed treatment for pests	.05	.09	.13	.12	—	.09	—	.08	.53	—	.03
Land preparation	.20	1.38	1.10	.18	—	.55	1.27	.32	.48	—	.12
Sowing and mulching	2.91	4.22	.26	1.90	—	1.00	7.76	3.17	1.49	—	.55
Gasoline, oil, and grease	.20	.86	.26	.12	2.23	.18	—	.32	.48	—	.10
Other costs	2.04	.86	.98	—	—	.55	—	—	.48	—	.16
Subtotal for seeding	27.37	18.79	8.33	15.89	19.89	26.03	20.91	12.40	22.76	29.73	3.75
Soil fumigation	—	7.67	3.16	6.58	—	6.67	—	3.43	4.22	—	.76
Fungicides for rust	1.17	1.21	.65	1.42	.98	1.74	.24	2.14	.10	—	.16
Preemergence herbicides	.10	1.47	.19	.12	.82	.41	—	.93	.19	—	.07
Postemergence herbicides	.26	2.07	.26	.77	—	.41	2.22	3.85	.58	—	.21
Handweeding	1.53	5.43	1.61	—	—	.09	—	1.58	.48	—	.25
Gasoline, oil, and grease	.20	.95	.26	.89	—	—	—	.11	.48	—	.08
Other costs	—	.86	.39	—	—	—	—	.10	—	—	.06
Subtotal for weeding, disease, & insect control	3.27	19.66	6.52	9.78	1.79	9.32	2.46	12.14	6.05	—	1.03
Power for irrigation	1.23	1.81	1.03	—	—	.55	6.73	.54	.10	—	.35
Labor for irrigation	.26	2.16	.52	.30	13.04	.09	—	.70	.48	—	.38
Repairs for irrigation	.10	.43	.71	.12	—	.09	—	.91	.05	—	.05
Subtotal for irrigation	1.58	4.40	2.26	.41	13.04	.73	6.73	2.15	.62	—	.58
Lifting seedlings	6.38	8.28	9.68	—	23.48	—	21.54	14.64	8.07	—	2.43
Tractor lifting and nursery transportation	—	2.07	—	3.02	—	5.48	—	.79	.67	—	.32
Gasoline, oil, and grease	1.02	1.21	.26	.89	1.09	.37	—	.95	.29	—	.12
Other costs	—	.86	.77	2.67	1.20	—	—	.32	—	—	.19
Subtotal for lifting	7.45	12.41	10.72	6.58	25.76	5.84	21.54	16.70	9.03	—	2.05
Culling and counting	—	10.34	12.94	—	—	7.31	.71	.47	7.59	—	.97
Culling table receiving	—	2.76	.13	—	—	—	—	2.37	1.10	—	.22
Culling table workers	—	2.33	—	—	—	—	12.44	9.90	1.10	—	1.22
Other costs	—	.86	.65	—	—	—	—	.55	—	—	.09
Subtotal for culling	—	16.29	13.69	—	—	7.31	13.15	13.30	9.79	—	1.19

See footnotes at end of table.

Table 1—*Component cost as a percentage of total cost per 1,000 loblolly pine seedlings produced on 10 bareroot forest nurseries in the South—Continued*

Component	Nursery 1	2	3	4	5	6	7	8	9	10	Average[1]
	Cost information % of total seedling cost per 1,000										*Dollars/1,000*
Wrapping paper/bags	2.96	1.38	.19	—[3]	5.38	1.55	1.23	2.30	2.88	—	.39
Root coating	.82	.26	.26	—	—	2.10	1.11	2.37	3.02	—	.24
Strapping/stitching	.05	.52	1.29	—	—	.64	.16	.55	.58	—	.08
Labor for packing	.51	3.10	2.19	—	—	1.83	—	.32	1.58	—	.23
Stacking	.51	.09	—	—	—	.64	—	.08	.53	—	.06
Other costs	—	.86	1.16	—	—	—	.59	1.27	.53	—	.14
Subtotal for packing	4.85	6.21	5.10	—	5.38	6.76	3.09	6.89	9.12	—	.77
Subtotal for lifting, culling, and packing	12.26	34.91	29.50	6.58	31.14	19.91	37.78	36.89	27.94	—	4.01
Seed for cover crop	.41	.43	—	.36	—	.09	1.43	.18	.29	—	.09
Fertilizer	2.15	.43	.26	.65	—	—	—	.43	.14	—	.12
Land preparation	.51	1.29	.32	.30	—	4.20	—	.05	.05	—	.12
Mowing	.20	1.29	.06	.06	—	—	—	.01	.14	—	.04
Irrigation	—	—	—	—	—	—	—	—	—	—	.00
Labor	1.84	.69	.19	—	—	.37	—	.29	.24	—	.10
Subtotal for cover crop	5.11	4.14	.84	1.36	—	4.66	1.43	.96	.86	—	.30
Sawdust	—	3.88	—	—	—	—	—	2.85	—	—	.41
Bark	—	—	1.16	1.07	—	—	2.57	—	—	—	.34
Other organic amendments	—	.34	—	—	—	—	—	—	—	—	.04
Subtotal for amendments	—	4.22	1.16	1.07	—	—	2.57	2.85	—	—	.19
Nursery supervisor, forestry aides, labor	17.01	9.05	11.75	24.78	19.24	21.83	16.04	20.03	26.36	—	3.15
Maintenance, utilities, depreciation	25.54	3.97	13.82	17.66	7.45	17.53	9.86	12.59	15.41	—	2.35
Workers' compensation	1.74	.86	—	—	—	—	.71	—	—	—	.21
Subtotal for administration	44.28	13.88	25.56	42.44	26.68	39.36	26.61	32.61	41.77	—	5.02
Other costs not listed	6.13	—	25.82	22.47	7.45	—	1.50	—	—	70.27	4.91
Total cost ($/thousand)	19.58	11.60	15.49	16.87	18.40	10.95	25.25	12.63	20.83	26.61	17.82

[1]Average of the entries in each row ($ per 1,000 seedlings).
[2]Lob. = loblolly pine.
[3]— = no cost estimate was reported for that category.

Conclusion

The data reported in this paper are an initial step in developing an understanding of the economics of bareroot seedling production. Future production studies will need to collect information on physical inputs for each operation (e.g., personhours, pounds of fertilizer) as well as costs. With this type of information, the relationship between inputs and quantity and quality of seedlings produced can be studied to optimize seedling production. Future studies could examine the economic relationship of lower planting density and precision planting to the output of high-quality seedlings.

The production of an adequate quantity of plantable seedlings to support industrial and public reforestation programs is of great importance. The investigation of nursery costs and the development of more efficient production of seedlings should be a concern of all forest nursery managers.

Literature Cited

1. Anonymous. Seedlings from state nurseries. For. Farm. 43(1): 14-15; 1983.
2. Cloud, M. C. A comparison of costs incurred in nursery production of improved and regular southern pine seedlings. In: Proceedings of Southeastern Area Forest Tree Nurserymen's Conference. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry; 1972: 77-82.
3. Guldin, R. W. Regeneration costs using container-grown southern pine seedlings. Res. Pap. SO-187. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1983. 29 p.
4. Rhody, J. P. Cost reduction in nursery operations. In: Proceedings of Southeastern Area Forest Nurserymen's Conference. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry; 1968: 7174.

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A Multiple-Compartment Tree Seed Tumbler-Drier

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A tumbler-drier that has several compartments so a number of seedlots can be dried at one time is described. Seeds can be conveniently removed for monitoring moisture content during drying.

For several years, we have been conducting laboratory and nursery tests of a modified stratification procedure for *Abies* seeds. This stratification treatment, which substantially improves germination of *Abies* and other dormant species, involves stratifying seeds (2° C) in a fully imbibed state for 1 month and then partially drying the seeds and stratifying for several more months (1). Laboratory drying was accomplished by spreading the seeds on screens or filter paper and occasionally stirring the seeds to expose wet surfaces to the air. Then, the seeds were weighed to monitor changes in their fresh weight. Since this process was labor intensive and slow, requiring about 8 to 10 hours, it was unsuitable for operational use.

We needed a device that would permit maximum exposure of all seed surfaces to the air without requiring external heating. The machine had to be able to handle a number of different lots, although not necessarily large quantities of each lot. It was also essential that seed containers be easily removable so that seed moisture content could be monitored during drying.

Description

The machine that evolved resembles a small "Ferris wheel" (fig. 1). Two parallel plywood disks, 915 millimeters (36 in) in diameter and spaces 356 millimeters (14 in) apart by plywood struts, are rotated on a central metal shaft. Fourteen 150-millimeter (6-in) circular holes, cut in opposing pairs in the large disks, support the ends of the 14 wire-mesh seed cylinders. Each cylinder is closed at one end and is lined with a removable sleeve made of fine plastic screen. The open end of each cylinder is bent outward to form a 12-millimeter (1/2-in) lip for securing the cylinder lid. The lid is fashioned from a circle of wire mesh glued to a liner of fine-celled polyurethane foam, the same diameter as the outer edge of the cylinder lip (figs. 2 and 3). Two spring-clip paper fasteners are used to attach the lid to the cylinder lip.

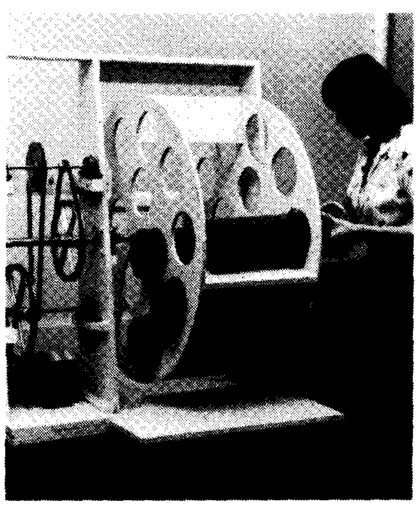

Figure 1—*Cylinders, each of which holds approximately 2 kilograms of seeds when half full, are easily removed from or inserted between the plywood disks. The series of reduction pulleys and motors are visible on the left.*

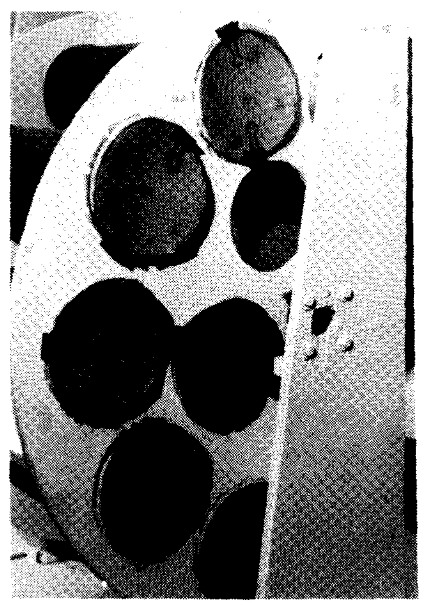

Figure 2—*Lids are secured to the lips of the cylinders with spring-clip paper fasteners. The foam liner provides a seal to prevent seed spillage.*

The solid steel shaft through the center of the large disks is driven by a $^{1}/_{3}$-horsepower electric motor, with speed reduction through

[1] The authors acknowledge the ideas and technical assistance of Sue Baker and Mike Balderson, British Columbia Ministry of Forests.

several pulleys (table 1, fig. 1) to approximately 10 to 12 revolutions per minute. A tumbling action is achieved and the seeds roll gently within the cylinders. Modifications to the drive mechanism are possible, but at least a $^{1}/_{3}$-horsepower motor is required to overcome the inertia of a fully loaded tumbler. If necessary, drying can be accelerated with a large room fan oriented to blow air across the cylinders as they rotate.

Best drying occurs when each cylinder is no more than half filled with wet seeds. Using all cylinders, 12 to 18 kilograms (25 to 40 lb) can be dried from 40- to 30-percent moisture content in less than 4 hours. Thus far, we have found no evidence of damage from the tumbling action. Although the device was designed for a specific seed-drying application, it could be used as a general seed drier. For example, it could be used to adjust the moisture content of freshly harvested seeds before they are placed in cold storage.

All materials are inexpensive and readily available, and the apparatus can easily be constructed in a short time (table 1). The three main advantages of this unit are: (1) the multiple compartments, which allow several seedlots to be dried at one time (a special consideration in processing seed orchard collections); (2) the inner

Table 1—*Parts list for multiple-compartment tumbler-drier*

Part	Number	Material	Size: Imperial	Size: Metric
			in	*mm*
Upright supports	3	¾-in (19-mm) plywood	4½ × 12 × 42	115 × 305 × 1,070
Large disks	2	⅝-in (14-mm) plywood	36 diameter	915 diameter
Disk spacers (struts)	4	¾-in (19-mm) plywood	15 × 6	380 × 152
Base	1	¾-in (19-mm) plywood	35 × 37½	900 × 950
Top brace	1	¾-in (19-mm) plywood	4½ × 37½	115 × 950
Cylinders	14	⅛-in (3-mm) wire mesh	6 × 18	150 × 460
Cylinder liners	14	Fine mesh plastic screen	6 × 18	150 × 460
Cylinder lids	14	⅛-in (3-mm) wire mesh		
		½-in (13-mm) polyurethane	6 × ½	150 × 10
Spring clips	28		1¼	
Shaft	1	Steel (solid core)	1 × 30	25 × 760
Shaft	2	Steel (solid core)	½ × 13¼	12 × 335
Pulleys	1	Metal	1⅜ × ½	35 × 12
	1	Metal	1-9/16 × ½	40 × 12
	1	Metal	2 × ½	50 × 12
	1	Metal	6 × ½	150 × 12
	1	Metal	9⅞ × 1	250 × 25
	1	Metal	11⅞ × ½	300 × 12
V belt	1	Rubber	38	965
	1	Rubber	40	1,015
	1	Rubber	48	1,220
Bearings	4	Pillow bearings	½	12
	2	Pillow bearings	1	25
Electric motor	1	⅓ hp, 115 V, 6.4 amp 1,725 r/min		
Wheels	4	Caster type	3	75

sleeves, which can be quickly removed from (and returned to) the cylinders for weighing (fig. 3), thus permitting changes in seed moisture content of the entire lot to be monitored without the need for taking subsamples; and (3) the drying at ambient temperature, which removes the possibility of accidental overheating.

Further details and mechanical drawings can be obtained from the senior author at British Columbia Ministry of Forests, Research Branch, 4300 North Road, Victoria, BC V8Z 5J3.

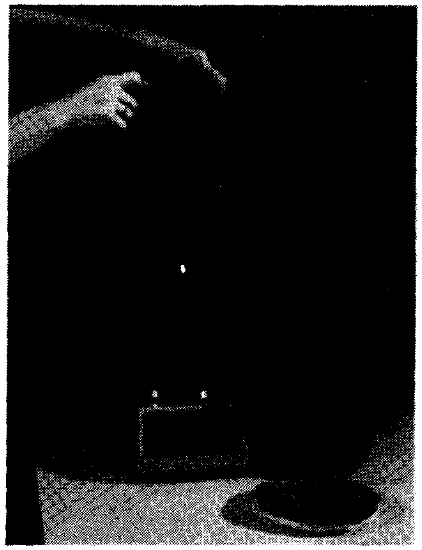

Figure 3—*Cylinders are lined with light-weight, plastic screen sleeves (closed at one end), which can be easily removed for weighing. Seed moisture content is monitored by frequent checks of seed fresh weight.*

Literature Cited

1. Edwards, D. G. W. A new prechilling method for true fir seeds Proceedings of the Intermountain Nurseryman's Association/Western Forest Nursery Association Combined Meeting Idaho 1980: 58-66: 1981.

Tree Planter's Notes, Vol. 35, No. 3 (1984)

A New Machine for Making Tar Paper Containers

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A machine has been developed that mass produces tar paper containers for growing drought-resistant nursery stock. The machine has reduced unit cost, produced a uniformly higher quality product with less material waste, and improved operator safety.

The Los Angeles County Fire Department, Forestry Division, has been growing drought-resistant nursery stock for over 60 years in tar paper containers. These containers measure $2^3/_4$ inches square by 12 inches deep and have proved to be an excellent, low-cost alternative to other plant container designs for dry land plantings when comparing soil volume, growing space, and ease of handling. This nonreusable container will last in the nursery for several years. It is biodegradable and can be used as a mulch if so desired.

Plant containers in the past were produced by a combination of hand-fed machine operation and hand labor. These operations required a 10-person crew and approximately 3,000 hours to produce 100,000 containers. The product was not entirely uniform, and there was an unacceptable amount of waste. The manufacturing process also exposed operators to burn injuries and toxic fumes from hot tar used as an adhesive.

The new machine (fig. 1) has cut labor needs by 80 percent. Unit cost has also been reduced to an average of 14 cents per container. Working in close cooperation with forestry personnel, the Millwright Shop of the Los Angeles County Mechanical Department designed and developed the machine. This machine allows 12-inch rolls of 30-pound roofing felt to be die cut, folded, and jet-melt glued in one continuous operation. The result (fig. 2) is a stronger, more uniform container produced with less labor. Also, operator safety has been greatly enhanced by elimination of exposure to heat and toxic fumes.

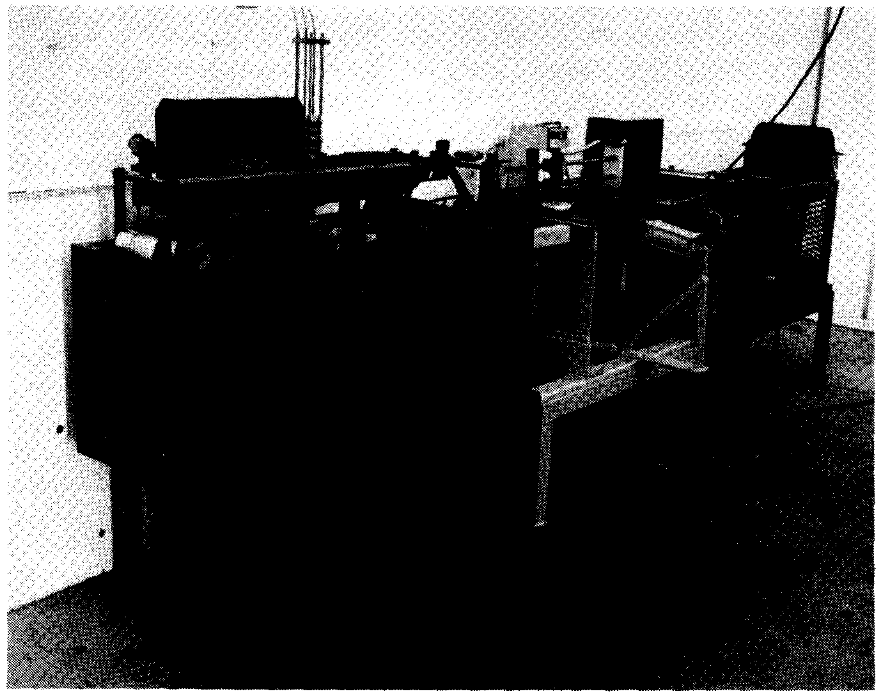

Figure 1—*Tar paper container manufacturing machine showing cutting, folding, and gluing sections.*

For more information, contact the Los Angeles County Department of Forester and Fire Warden, Forestry Division, P. O. Box 3009, Terminal Annex, Los Angeles, CA 90051.

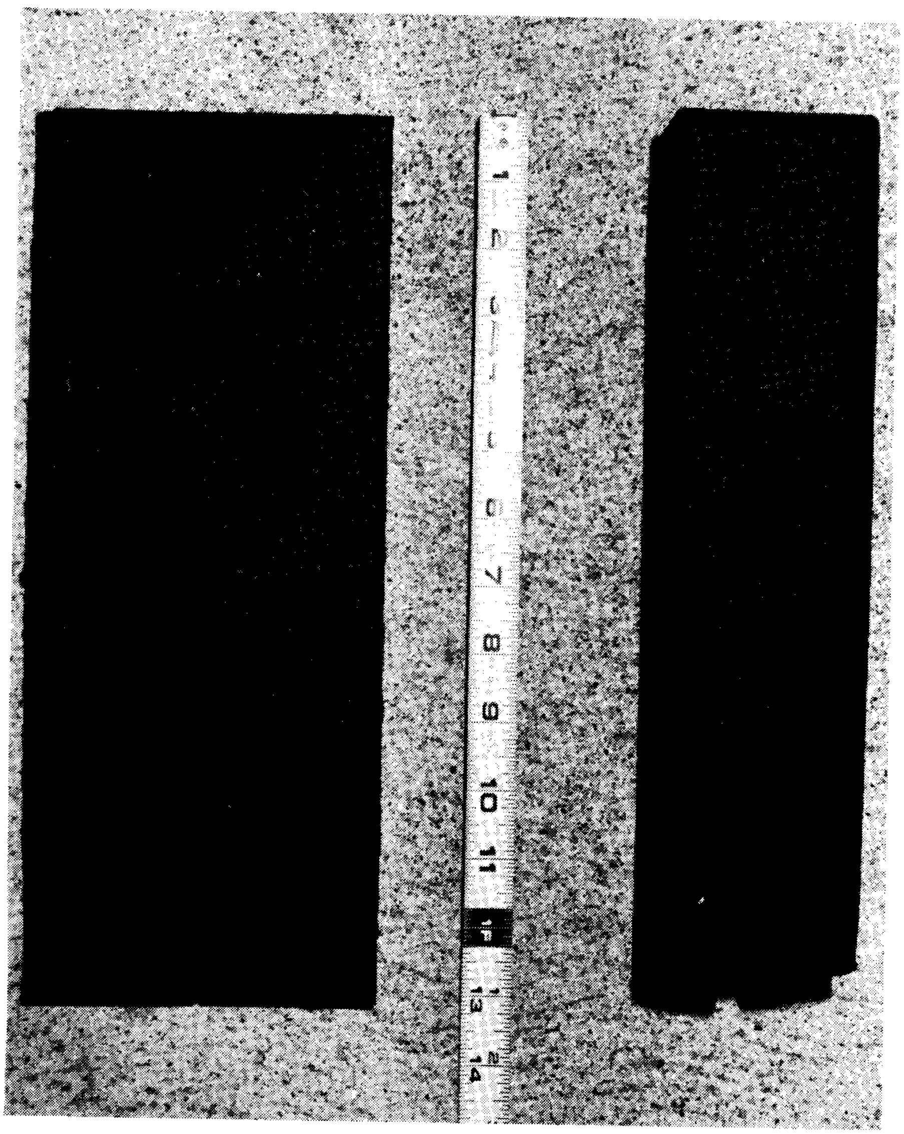

Figure 2—*Two views of the tar paper container: Folded for storage as it comes from the machine (left) and folded and ready for use (right).*

Mowing Versus Mechanical or Chemical Weed Control in Sugar Maple Afforestation

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Ten-year cumulative height increments of planted sugar maple were 156 and 366 centimeters, respectively, in plots that were mowed four times a year for 9 years or rototilled for 4 years and sprayed with simazine for 5 years. Elimination of competing vegetation with applications of propyzamide and simazine resulted in better height increments in 1 year than did mowing during the previous 4 years.

Many plantation owners mow between the rows of planted trees believing that this will improve tree growth. In farming areas, it may be mandatory to cut the weeds to prevent the spread of seeds onto adjacent agricultural fields. Mowing is also beneficial because it reduces the shelter for rabbits and mice and thereby helps to reduce browsing and stem girdling. However, mowing removes only the aboveground parts of the weeds, while the roots remain undisturbed and continue to compete actively for moisture and nutrients.

This report presents the results of a study that compared mowing with chemical and mechanical elimination of herbaceous vegetation on the 10-year survival and growth of planted sugar maple (*Acer saccharum* Marsh.) seedlings.

Methods

In spring 1973, 2+0 sugar maple seedlings were planted in two fields in southwestern Ontario with soils of sandy loam and clay loam. The fields were plowed in the summer and disked several times before spring planting. Both plantations were divided into three plots, each containing 288 seedlings. One of the following weed control treatments was applied to each plot four times per summer in each of the first 4 years after planting: (1) Rototilling between the rows and manual hoeing around the trees, (2) spraying 2.5 kilograms per hectare of active paraquat (Gramoxone) on the vegetation within a circle 60 centimeters in diameter around the tree seedlings, or (3) mowing between the rows and around the seedlings. No weed control was applied during the fifth growing season. In November of the fifth year, 2.1 kilograms per hectare of active propyzamide (Kerb) were broadcast over the mowed plot on the sandy loam soil. Starting in April of the sixth growing season, 4.5 kilograms per hectare of active simazine (Princep) were broadcast annually over all plots on both soils, with the exception of the mowed plot on the clay loam soil. This plot was mowed four times during the sixth growing season. In November of the sixth year, the plot was split. On one-half of the plot, the weeds were mowed four times annually for the next 4 years. On the other half, 2.1 kilograms per hectare of active propyzamide were broadcast in November; 2.1 kilograms per hectare of active glyphosate (Roundup) were sprayed on the vegetation in June and August of the seventh growing season; and 4.5 kilograms per hectare of active simazine were broadcast in April of the seventh to tenth growing seasons. Survival and height of all trees in all plots were recorded each autumn. Wire sleeves were placed around all stems in the rototilled and mowed plots on the sandy loam soil to protect the trees from stem girdling by rabbits. No sleeves were placed around the trees in the paraquat-treated plot.

Results and Discussion

Extensive stem girdling by cottontail rabbits (*Sylvilagus floridanus* Allen) in the paraquat plot on the sandy loam soil made treatment comparisons meaningless and the survival and growth data from this plot are therefore excluded from this report. Table 1 shows seedling survival by weed control treatments and years since planting. No single cause was responsible for the mortality. Most seedlings died from natural causes, while few died from repeated browsing or cutting with the lawnmower.

At the time of planting, all plots were completely weed-free. In autumn of the first year, however, a dense cover of quackgrass (*Agropyron repens* L. Beauv.) invaded the mowed plot on the sandy loam. On the clay loam, the mowed plot and untreated parts of the paraquat plot were invaded by ragweed (*Ambrosia artemisifolia* L.), lamb's quarters (*Chenopodium album* L.), wild carrot (*Daucus carota* L.), and quackgrass. During the next 3 years, this vegetation changed to mainly quackgrass.

In the mowed plots, height growth started in the middle of May and finished at the end of June. In the weeded plots, height growth also started in the middle of May, but continued in spurts, interspaced with short resting periods, until the end of August.

Following the suspension of the original weed control treatments at the end of the fourth growing season, sugar maple growth slowed during the fifth year in all plots. However, the growth reduction was smallest in the rototilled plots, because they were weed-free at the beginning of the year and serious competition from the invading weeds was delayed until the end of the growing season (figs. 1 and 2).

After the elimination of all weeds in the mowed plot on the sandy loam soil by an autumn application of propyzamide and a spring application of simazine, the sugar maple seedlings grew 67 centimeters the next year, while their cumulative growth during the previous 5 years had been 61 centimeters (fig. 1).

Similar results were obtained after the elimination of the competition on one-half of the mowed plot on the clay loam soil (fig. 2). Following the application of propyzamide and glyphosate during the first growing season, height growth was 65 percent greater in the chemically weeded half of the plot than in the mowed half. After the plot was split, cumulative 4-year height increments in the chemically weeded and mowed halves of the plot were 197 and 68 centimeters, respectively.

The detrimental effects of weed competition on hardwood tree growth are well documented (1, 2, 3, 4). However, insufficient information is available on the relative importance of competition for light, moisture, nutrients, or the possible interference with tree growth by allelopaths or toxins produced by the weeds. In our plantations, the sugar maple foliage in the mowed plots was yellowish (Munsell color chart value 5.0 Y, 7/6), while that in the

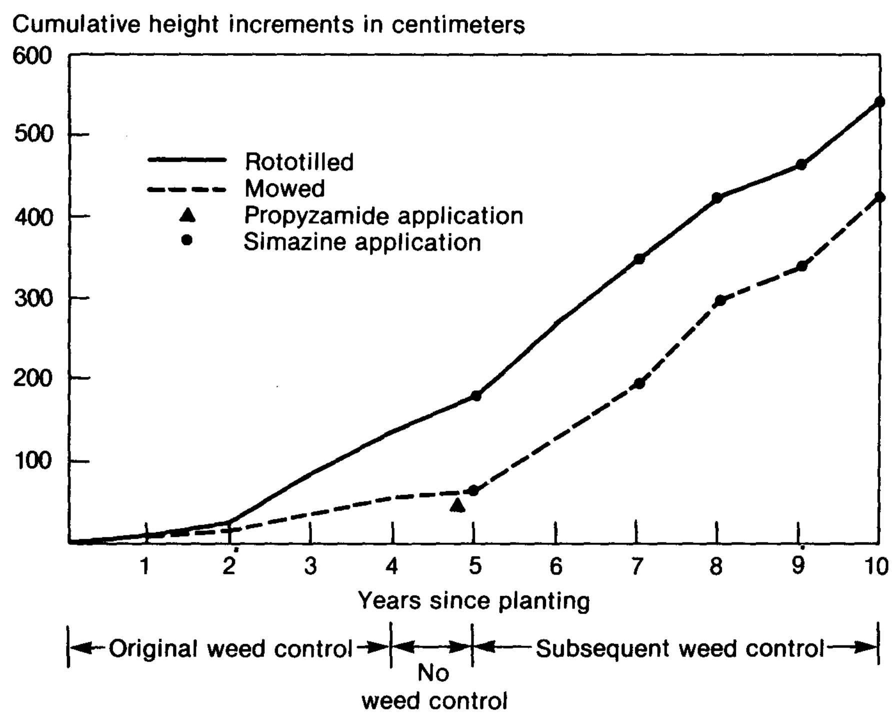

Figure 1—*Cumulative height increments since planting of sugar maple seedlings (2+0) by weed control treatments and by years since planting (sandy loam soil).*

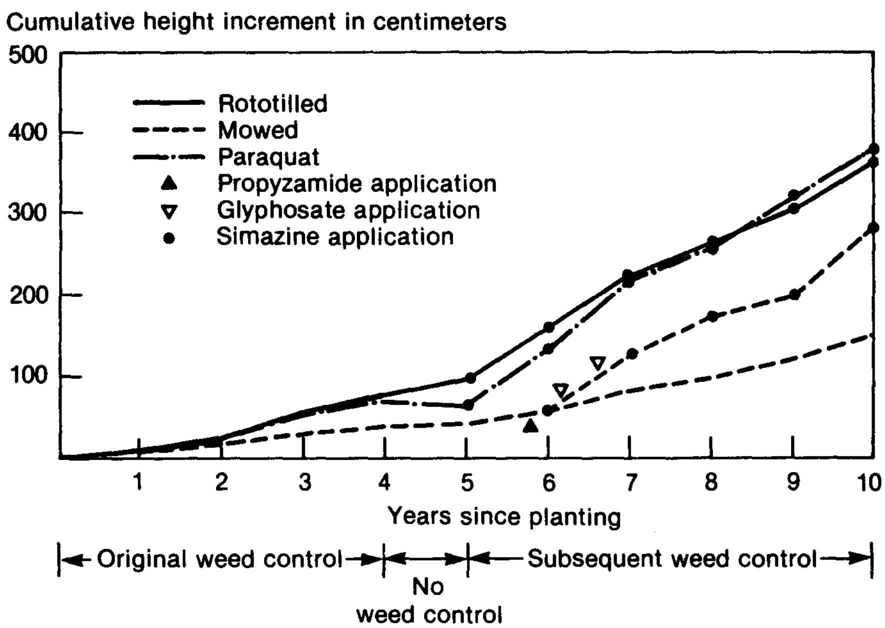

Figure 2—*Cumulative height increments since planting of sugar maple seedlings (2+0) by weed control treatments and by years since planting (clay loam soil).*

Table 1—*Percentage of survival by weed control treatments and years since planting*

	Sandy loam			Clay loam			
Years since planting	Rototilled plus simazine	Mowed	Mowed plus propyzamide and simazine	Paraquat plus simazine	Rototilled plus simazine	Mowed	Mowed plus propyzamide, glyphosate, and simazine
1	96	92	—[1]	98	99	98	—
2	89	85	—	97	94	95	—
3	87	83	—	96	93	94	—
4	87	80	—	95	92	93	—
5	85	78	—	95	90	88	—
6	85	—	78	95	90	88	—
7	85	—	78	94	90	88	88
8	85	—	78	94	90	87	86
9	85	—	78	94	90	87	86
10	85	—	77	94	90	87	84

[1] — = not applicable or not available.

rototilled and chemically weeded plots was dark green (Munsell color chart value 5.0 GY 4/4). Before the mowed plot was split, the N contents of the sugar maple leaves in the rototilled and mowed plots were 1.91 and 1.31 percent, respectively. Elimination of the weed competition increased the N content of the leaves to 2.11 percent, while the N content of the leaves of trees growing in the mowed half remained at 1.31 percent.

Conclusion

More research is needed to determine the processes by which the weeds interfere with tree growth. Nevertheless, the results of this study clearly show that mowing is no substitute for mechanical or chemical elimination of weeds, because it fails to remove the negative influence of the herbaceous competition on tree growth.

Literature Cited

1. Byrnes, W. R. Site preparation and weed control. In: Black walnut culture. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1966: 2027.

2. Lane, R. D.; McComb, A. L. Effects of grass competition upon the establishment of hardwood plantations in Iowa. Res. Bull. 399. Ames, IA: Iowa State University, Agricultural Experiment Station; 1953: 435-459.

3. von Althen, F. W. A guide to hardwood planting on abandoned farmland in southern Ontario. Sault Ste. Marie, ON: Department of the Environment, Canadian Forestry Service; 1979.43 p. Special handbook.

4. von Althen, F. W. Site preparation and post-planting weed control in hardwood afforestation: white ash, black walnut, basswood, silver maple, hybrid poplar. Inf. Rep. O-X-325. Sault Ste. Marie, ON: Department of the Environment, Canadian Forestry Service; 1981. 17 p.

Silverberry Seed Pretreatment and Germination Techniques

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Two dormancy mechanisms were found in silverberry seeds- a germination inhibitor and the seed being negatively photoblastic. The inhibitor is leachable with warm water; and the negative photoblasticism can be overcome by covering the seeds with soil.

Lands disturbed by the mining and extraction of oil sands in northeastern Alberta are normally reclaimed with native woody species. However, several potentially useful species such as silverberry (*Elaeagnus commutata* Bernh.) are currently not used to their full potential because of problems associated with overcoming seed dormancy.

Silverberry is ideally suited for land reclamation purposes because it is a thicket-forming shrub useful for wind and water erosion control. It grows well on hillsides, erosion gullies, and roadcuts where the soil is dry and low in nutrients (2), a soil characteristic generally found on mined sites. As well, silverberry fixes nitrogen under most conditions (6), which makes it a desirable nurse crop for land restoration.

The nature of seed dormancy in silverberry has been studied, but the conclusions have varied from nondormant (4) to coat-imposed dormancy (3) to the possible presence of a chemical inhibitor in the seeds (1, 5). This study was initiated to further examine and overcome seed dormancy in silverberry.

Materials and Methods

Silverberry fruits were collected in October 1982 from Cline River, Alberta. The cleaned seeds were stored at 4° C until April 1983 when the test was conducted. Seed pretreatment consisted of soaking the seeds in warm water for 0, 2, 4, and 6 days. For each treatment, a 1-liter jar was filled with warm water at 50° C. Approximately 450 seeds were then submerged in the water. The jar was left undisturbed at room temperature for 24 hours. After 24 hours, the water (now cooled to approximately 24° C) was drained. The jar was then refilled with fresh, warm (50° C) water and the seeds vigorously agitated and rinsed. This process was repeated three times. The seeds were again resoaked in warm (50° C) water. The agitating and rinsing were repeated after every 24 hours until the specified pretreatment time period was completed.

Then, all the seeds, including the control, were surface-treated with 3-percent hydrogen peroxide just before sowing. The seeds were immersed in the hydrogen peroxide solution for 3 minutes and then rinsed several times with sterile water. This treatment ensured that the seeds were pathogen-free at the time of sowing.

Two methods of seed germination were tested: "No soil" and "soil." In the "no soil" method, the seeds were placed directly on top of moistened filter papers in petri dishes. The dishes were covered to retain moisture. Water was added as required to maintain a moist surface. In the "soil" method, aluminum foil plates were half filled with a moist, 2:1 soil mixture of peat moss and vermiculite. The seeds were placed on the surface and covered with 1 centimeter of soil. The plates were then covered with clear plastic lids to prevent seed desiccation.

The germination test was conducted at room temperature. It consisted of four replicates of each combination of pretreatment duration and germination method. Each replicate consisted of 50 seeds. During the test period, seeds that became moldy were washed in a 3-percent hydrogen peroxide solution, rinsed with sterile water, and placed into new germination containers. Seeds that failed to germinate after the 21-day test period were cut open and examined for seed viability.

Results

Germination began 5 days after sowing. The results are presented in figure 1. The germination capacity was calculated based on the actual number of viable seeds sown per treatment replication. The seedlot has a 95.8-percent viability as determined by the cutting test.

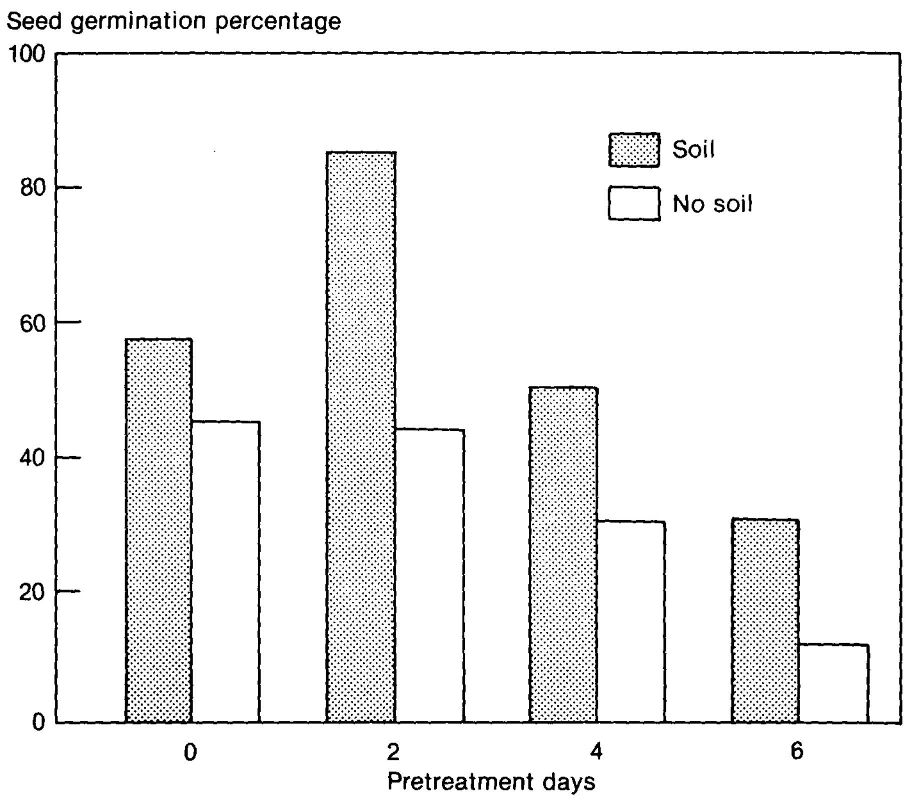

Figure 1—*Germination percentage of silverberry seeds as affected by pretreatment and germination techniques.*

Analysis of variance showed that the effects of soaking duration on seed germination were statistically significant. Significant differences were also found between the "soil" and "no soil" germination methods. The highest germination (85.3%) occurred on the seeds sown in soil after a 2-day warm-water soaking pretreatment. The germination capacity in both the sowing methods, however, decreased proportionately with prolonged soaking.

Discussion and Conclusions

Silverberry seeds have dual dormancy mechanisms: A germination inhibitor is present, possibly within the inner tissues and pericarp of the seeds and the seeds are negatively photoblastic (i.e., germination is inhibited by light and the seeds are thrown into a state of secondary dormancy).

The inhibiting substance is water soluble and it can be readily leached out, thus eliciting germination if the seeds are kept in the dark. Leaching can be accomplished by soaking the seeds in warm water, which is initially at 50° C, for 24 hours. They are then washed and rinsed thoroughly before resoaking in warm water for another 24 hours. Then the seeds are washed and surface-sterilized with a 3-percent hydrogen peroxide solution. For optimum germination, the seeds should be buried 1 centimeter deep.

Literature Cited

1. King, P.; Grainger, G.; Straka, A. Testing of seed pregermination treatments for selected native shrub species. Edmonton, Alberta: Alberta Energy and Natural Resources, Forest Service; 1983: 3-11.
2. Moore, A. W. Note on non-leguminous nitrogen-fixing plants in Alberta. Can. J. Bot. 42: 952-955; 1964.
3. Shoemaker,J. S.; Hargrave, P. D. Propagating trees and shrubs from seed. Cir. 21. Edmonton, Alberta: University of Alberta, Department of Extension; 1936. 22 p.
4. Simonson, G. Seed technology study: Revegetation research-progress report of work accomplished in 1975. Edmonton, Alberta: Alberta Oil Sands Environmental Research Program. 1976. 350 p.
5. Vories, K. C. Growing Colorado plants from seed: A state of the art-Volume 1: Shrub. Gen. Tech. Rep. INT-103. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 80 p.
6. Whysong, G. L.; Bailey, A. W. Production and nitrogen content of herbage in a silverberry *(Elaeagnus commutata)* community compared to adjacent grassland and forest communities. Can. J. Plant Sci. 55: 801-808; 1975.

Tree Planter's Notes, Vol. 35, No. 3 (1984)

Sycamore Seedlings From the Nursery -- Not the Same Genetic Composition as the Collected Seedlot[1]

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The genetic composition of bulked sycamore seedlots is altered when smaller or larger diameter seeds are removed. The family composition of seedlings from bulked seedlots is different from the composition of individual family seedlots because families germinate at different rates.

Tree improvement programs stress the importance of controlling the genetic composition of planting stock in order to achieve genetic gain. By collecting seeds from seed orchards, it is possible to control, to some extent, the genetic composition of seedlots. If seed orchard seeds are bulked, the family composition of the resulting seedlings may be different from the average of the original lots. These differences can be caused by seed handling practices and by different germination rates among the families in the bulked seedlot. Removing lighter density seeds from seedlots has improved the germination of the remaining seeds for some species (1, 2). However, studies have also shown that seed sizing can alter the genetic composition of bulked seedlots (3, 4).

Removal of the lighter density seeds of American sycamore *(Plantanus occidentalis)* improves the germination of the remaining seeds (2). Sizing seeds on the basis of density is not a common practice in commercial nurseries, but removing the smaller seeds with slotted sieves is sometimes done. The objective of this study was to determine if the genetic composition of seedlings from bulked seeds can be altered (1) by removal of the smaller seeds using slotted sieves and (2) by families germinating at different rates.

Methods

Sycamore fruits were collected from 10-year-old grafts from the Catawba Timber Co. sycamore seed orchard at Catawba, S. C., in December 1978. Fruits were collected from one ramet of each of 12 clones. The fruits were air-dried for 5 weeks and then broken apart for seed separation and cleaning. Each family seedlot was sorted through a series of slotted sieves into four classes on the basis of seed diameter. The diameter classes were greater than 1 /16 inch (1.59 mm), 1/16 to 1/20 inch (1.27 mm), 1/20 to 1/24 inch (1.06 mm), and less than 1/24 inch. For each family, the weight of seeds in each size class was recorded to determine the percentage of total weight in each size class (table 1).

Table 1—*Seed size distribution by percentage of total weight for 12 open-pollinated sycamore family seedlots*

	Seed size			
Family	<1/24 in.	1/24-1/20 in.	1/20-1/16 in.	> 11/16 in.
	----- % of total weight -----			
A	5	9	57	29
B	9	23	62	6
C	9	25	63	3
E	23	36	41	0
F	0	0	44	56
J	7	20	65	8
K	4	16	69	11
Q	14	34	52	0
S	4	14	69	13
U	17	34	49	0
V	0	0	52	48
X	0	0	34	66

The seedlots were subjected to a germination study in the spring after the seeds had been moist-stratified. Fifty seeds from each seed size-clone combination (35 lots) were allowed to germinate in a cup of water for 22 days. The fungicide Ferbam was added to the water to prevent mold buildup. Germination counts were made after 22 days.

Results and Discussion

Seed size distribution differs by family (table 1); therefore, seed sizing can alter the genetic composition of a bulked seedlot. If all seeds smaller than 1 /24 inch were

[1] Paper number 8863 of the journal Series of the North Carolina Agricultural Research Service, Raleigh.

removed from a bulked seedlot consisting of equal weights of seeds from the 12 families in table 1, only 3 families would lose more than 10 percent of their total weights. If all seeds less than 1 /20 inch in diameter were removed, families F, V, and X would have no seeds removed, while over 45 percent of the seed weight from families E, Q, and U would be removed. Use of only the largest diameter class would severely restrict the genetic base of the seedlot. Four families constitute 83 percent of the total weight in this size class.

The germination study showed that seeds from different clones had significantly different germination rates (tables 2 and 3). If an equal number of seeds from each of the 12 families were planted, not all of the 12 families would be equally represented in the resulting seedling crop. Seventy percent of the seedlings would be offspring of families E, D, K, U, and S. Families U and S alone would account for 31 percent of the seedlings. It is invalid to assume a bulked seedlot consisting of equal amounts of seeds from each family will produce equal numbers of seedlings from each family.

To keep a seedling crop from being predominantly the offspring of a few individuals, sycamore can be planted by family. In this way, each family seedlot can be sown with regard to its particular germination rate. The seedlings could then be lifted by family and either maintained separately or bulked for outplanting. An advantage of sowing and lifting by family is that families can be matched to sites where they perform best.

Table 2—*Percentage of germination for 12 open-pollinated sycamore family seedlots*

	Seed size				
Family	<1/24 in.	1/24–1/20 in.	1/20–1/16 in.	> 11/16 in.	Mean
		% of germination			
A	—[1]	0	0	2	1
B	4	2	6	—	4
D	20	8	32	—	20
E	14	14	18	—	15
F	—	—	16	2	9
J	10	10	14	12	12
K	—	20	12	24	18
Q	2	4	16	—	7
S	26	22	50	36	32
U	18	28	30	—	25
V	—	—	0	0	0
X	—	—	18	8	13

[1]— = no germination.

Table 3—*Significant family germination differences at P = 0.05*

Family	V	A	B	Q	F	J	X	E	K	D	U	S
Percent	0	1	4	7	9	12	13	15	18	20	25	32

[1] Families underlined by the same line are not statistically different with a probability of 0.05.

Conclusions

Seed size distribution differs by family for sycamore. Because of these distribution differences, removing certain sizes of seeds from a bulked seedlot will alter the family composition of the lot.

Germination rates also differ by family. Sowing a bulked seedlot consisting of an equal number of seeds from various families will produce unequal numbers of seedlings from each family.

The only way to be sure of the genetic composition of a seedling crop is to sow the seeds by family. The separate families can then be bulked to match genotype and site.

Literature Cited

1. Bonner, F. T.; Switzer, G. L. Upgrading yellow-poplar seeds. Res. Note 129. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1971.
2. Bonner, F. T. Collection and care of sycamore seeds. South. J. of Appl. For. 3(1): 23-25; 1979.
3. Hellum, A. K. Grading seed by weight in white spruce. Tree Plant. Notes. 27(1): 16-17, 23-24; 1976.
4. Silen, R.; Osterhaus, C. Reduction of genetic base by sizing of bulked Douglas-fir seedlots. Tree Plant. Notes. 30(4): 25-28; 1979.