1986

Greenhouse production of quaking aspen seedlings

K.E. Burr

Greenhouse Production of Quaking Aspen Seedlings[1]

Karen E. Burr [2,3]

Abstract.--This paper describes the procedures for greenhouse production of container grown quaking aspen seedlings used at the Colorado State Forest Service Nursery in Fort Collins, Colorado. Topics include; seed collection and sowing, transplanting, thinning, exponential growth, hardening, pruning, grading, and a comparison of spring and winter crop growth rates.

INTRODUCTION

The Colorado State Forest Service Nursery in Fort Collins, CO, began greenhouse production of container grown quaking aspen (*Populus tremuloides* Michx.) seedlings on an experimental basis in the fall of 1983. Several crops have been grown since that time and many experiments have been conducted to improve the production process. The information presented here is a composite of the knowledge gained from those several crops and experiments, and represents the best methodology for producing quaking aspen seedlings developed thus far by the nursery.

SEED COLLECTION

The Colorado State Forest Service Nursery collects aspen seed rather than purchasing it, because large quantities of seed can be quickly collected from nearby sources in a good seed year. The seed will remain viable for several years when properly cleaned and stored.

Female aspen clones typically produce large quantities of non-dormant seed having 90 percent or greater gremination every 3 to 5 years (U.S. Department of Agriculture, Forest Service 1974).

Seed matures late May to mid-June at 2350 m elevation west of Fort Collins and is collected just prior to release. When the capsules can be split open by hand fairly easily along the lines of suture and the seeds within are tan, rather than the pale green color of immature seeds, branches bearing catkins are pruned from selected seed trees and brought indoors. Seed shed and cleaning should be located in a clean, warm room with low relative humidity, low air movement, and minimal other concurrent uses.

The ends of the collected branches are recut and placed in water to keep the leaves from drying. Pieces of dried leaves are very difficult to separate from the seeds during the cleaning process. Supplying water to the branches also permits the capsules to continue developing, and seed release occurs within 7 to 10 days. Procedures for cleaning aspen seed with a series of soil screens have been described by Roe and McCain (1962). Their approach is improved with the use of a canister vacuum cleaner which can both collect the seeds once shed and supply the forced air needed for cleaning.

Seed moisture content is too high at the time of release for successful long-term storage. If the seed is allowed to come to equilibrium with the atmosphere by waiting 1 to 2 days before vacuuming and cleaning, no further drying measures are usually necessary. Seed moisture content of 6 to 8 percent of fresh weight permits 4 to 6 years storage in air tight containers at $-18^{\circ}C$ (Fechner et al. 1981, Wang 1973). Aspen seed can be maintained with freezer storage much longer than at storage temperatures above freezing (Benson and Harder 1972).

The quality of the seed, whether just collected or retrieved from storage, can be quickly checked. Radicle and hypocotyl elongation are evident in 48 hours from aspen seed sown on moist blotter paper in a covered petri dish at $20^{\circ}C$ (McDonough 1979). It is best to determine seed

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[1]Paper presented at the Intermountain Nurseryman's Association Meeting, Fort Collins, Colorado, August 13-15, 1985.

[2]Graduate Research Assistant, Department of Horticulture, Colorado State University, Fort Collins, CO.

[3]Acknowledgements: Sincere thanks to Marvin Strachan and James Fischer for providing an invaluable work experience and for their help in conducting this research; to the Rocky Mountain Forest and Range Experiment Station and Dr. Richard Tinus for financial and editorial assistance; and to Drs. Louis Bass and Philip Stanwood, U.S. National Seed Storage Laboratory, for use of seed storage facilities.

quality prior to sowing or storing, as well as to monitor stored seed periodically.

The cost incurred by the Colorado State Forest Service Nursery in 1984 for seed tree selection and monitoring, and seed collection and cleaning, was $2.20 per gram of pure seed. This is based on an hourly wage of $10 and the discontinuing of cleaning when a purity of at least 90 percent is reached. There were 5300 seeds per gram at a moisture content of 8.4 percent in this particular collection, as calculated from two samples of 50 seeds each.

SOWING

The greenhouses at the nursery are fully controlled with fan and pad cooling, overhead irrigation systems through which fertilizer is applied, supplemental CO_2, and intermittent lighting for photoperiod control. A standard greenhouse environment used for growing several species of containerized conifers at the nursery is also used for aspen production (fig. 1).

Aspen seed is sown directly onto dry Forestry Mix (W. R. Grace Co.) in Colorado Styro-Blocks (30, 458 cc cavaties) after the blocks have been machine filled with mix and moved to the greenhouse benches. Sowing is done by hand using a salt shaker with only one hole (1.5 to 2.0 mm diameter) open. An average of five seeds pass through the hole per shake. This sowing rate is based on germination of 85 to 90 percent. The number of empty cavities is too great if an average of 2 to 3 seeds are released because of a wide range in the actual number of seeds released each shake. Seeds can be sown with a salt shaker, one shake per cavity, at the rate of approximately 9000 cavities per hour.

No surface treatment is applied after the seeds are sown, such as the addition of a layer of perlite or grit. Seedling emergence can be inhibited by a sowing depth of only 2 mm (McDonough 1979). The Styro-Blocks are irrigated immediately following sowing with the overhead mist system until soaked through and are then irrigated as needed, typically three times per day, to prevent the surface of the mix from drying during the first 12

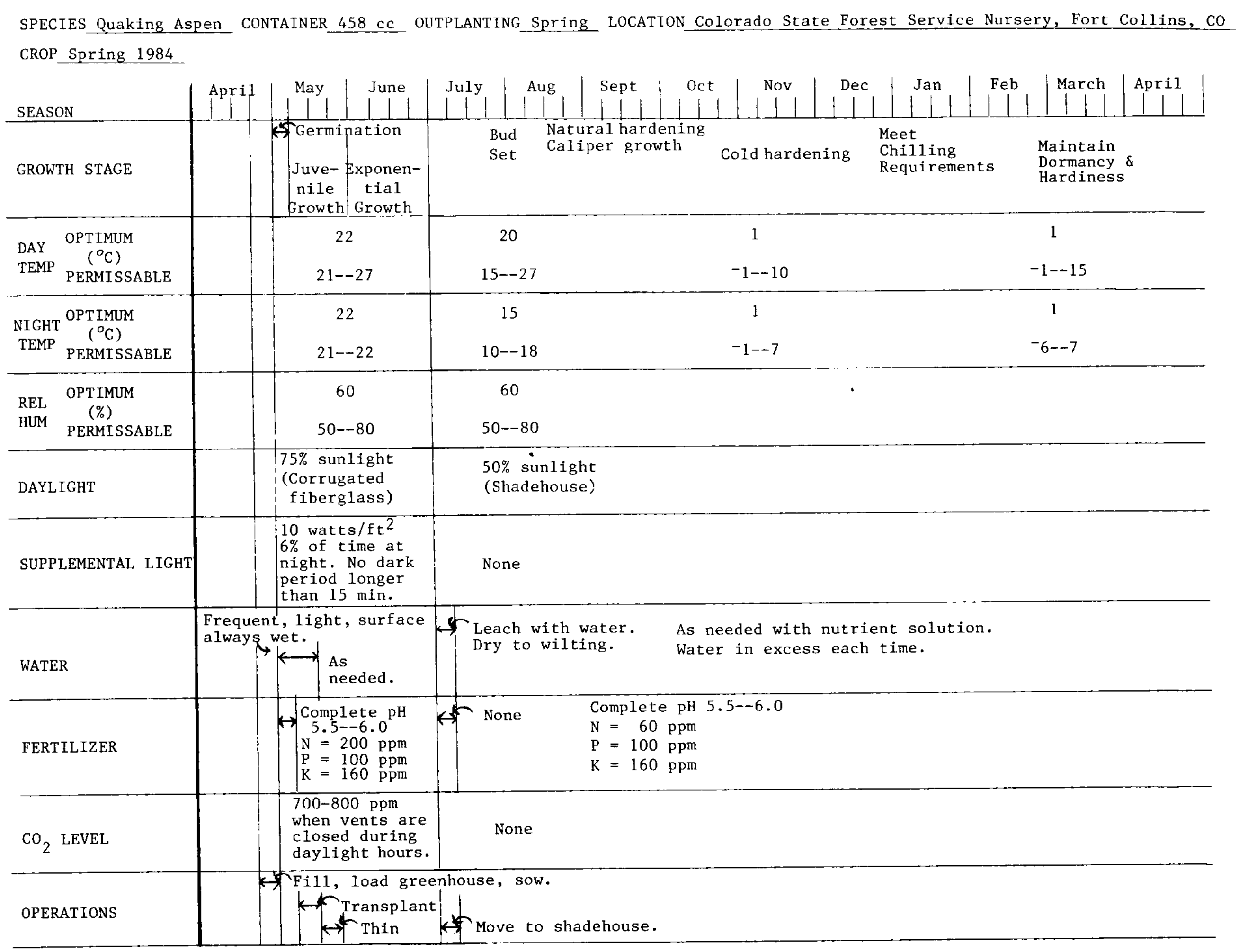

Figure 1.--Growing schedule of the spring 1984 crop of quaking aspen seedlings at the Colorado State Forest Service Nursery.

days. After that time, seedlings are irrigated with fertilizer approximately twice per week.

GERMINATION AND TRANSPLANTING

One week after sowing, germination is complete and seedlings are approximately 0.5 cm in height with cotyledons only. Seedlings reach an average height of 1.0 cm (range = 0.8 to 1.3 cm) and the first pair of true leaves is visible at the end of the second week after sowing. Root systems are fibrous and two-thirds the length of the above ground portion of the seedling at this time.

The aspen are transplanted from cavities with excess seedlings to empty cavities during the second week (fig. 2). Seedlings are lifted with the blade of a small knife and placed in a dibble hole in another cavity. An estimated 5 percent of the total cavities sown with a salt shaker require transplants, and much of the time required for transplanting is spent locating empty cavities. Cavities can be examined and the empty ones filled at the rate of 1800 cavities per hour. However, if empty cavities are already identified, transplanting at the rate of 300 seedlings per hour is possible.

Seedlings show no short term ill effects from transplanting, such as wilting, when transplanted at 1 cm tall. Transplanted seedlings (150) and non-transplanted seedlings (150) were monitored until reaching an average height of 51 cm to determine if there were any long term effects of transplanting. Seedlings transplanted at 1 cm tall were not significantly (p = 0.5) different in mean height, caliper, or mortality rate than non-transplanted seedlings thinned at 1 cm tall.

	Height	Caliper	Mortality
	cm	mm	%
Transplanted seedlings	53	4.1	7.3
Non-transplanted seedlings	49	4.0	5.3
Statistical test	t-test	t-test	Chi^2

Transplanting an entire crop from seed sown in flats is not recommended. Not only is it unnecessary for seedling establishment, but because the seedlings grow very fast, it is nearly impossible to transplant large numbers of seedlings before overcrowding in the flats adversely affects seedling morphology.

THINNING

Thinning to one per cavity is done early in the third week after sowing when the seedlings are at a height of 1.0 to 1.5 cm. Because the seedlings double in height, from 1.0 to 2.0 cm,

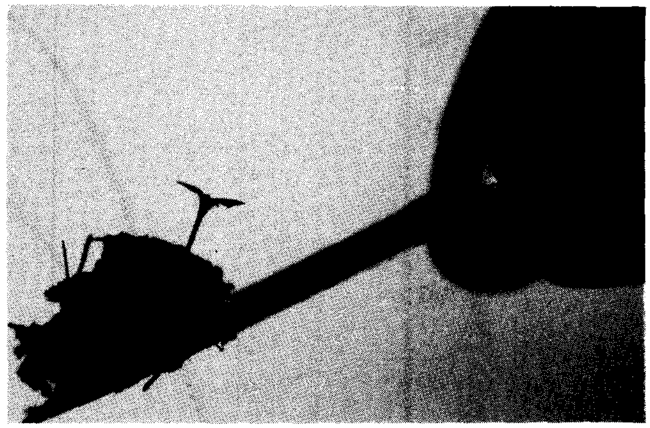

Figure 2.--Transplanting a quaking aspen seedling two weeks after sowing. Seedling height is 8 mm.

during the third week, they are within this height range for only 3 to 4 days. It is extremely important to thin before the seedlings become taller than 1.5 cm. High seedling density affects seedling morphology very rapidly when seedlings within a cavity begin to compete as they increase in size. Early competition results in accelerated height growth associated with poor caliper development. Seedlings with this spindly form are unable to remain upright after irrigating because of the weight of the water on the foliage. Taller upright seedlings then suppress shorter ones.

When determining how many aspen to sow at any one time, it is better to stagger the sowings than to sow more than can be thinned in a 4-day period. Seedlings can be thinned at the rate of 400 cavities per hour.

EXPONENTIAL GROWTH

Aspen seedlings sown in the greenhouse in spring or summer double in height the second, third, and fourth weeks after sowing, triple in height the fifth week, and then maintain a growth rate of approximately 1.5 cm per day until hardening is begun (fig. 3). Seedlings reach an average height of 45 cm in 8 weeks and average greater than 60 cm tall in 10 weeks. This rate of height growth is approximately twice that reported by others growing quaking aspen seedlings (Fisher and Fancher 1984, Okafo and Hanover 1978) and naturally established seedlings may require 4 years or more to reach an average height of 45 cm (Williams and Johnston 1984).

A major concern during this period of rapid growth is providing enough water to the roots. The leaves shed a great deal of water from the overhead mist system as the canopy closes. Large seedlings in the Styro-Blocks (fig. 4) need to be irrigated 1.5 to 2 hours to completely soak the

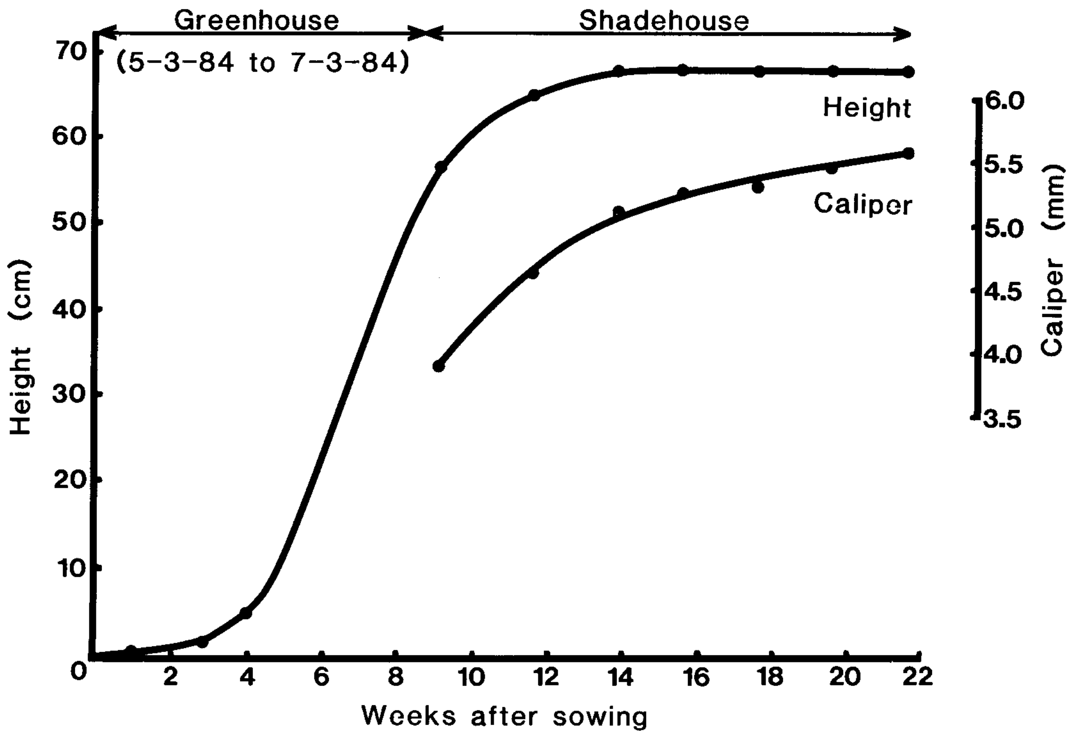

Figure 3.--Height and caliper growth of the spring 1984 crop of quaking aspen sown May 3, 1984. Seedlings were greenhouse grown until July 3, 1984 and then moved to a shadehouse for hardening. The rate of height growth between weeks 5 and 8 is 1.5 cm per day.

the containers. This is 3 to 4 times longer than is necessary prior to canopy closure. If the seedlings are not thoroughly irrigated, shallow root systems develop which can lead to frequent wilting, slowed growth, and the inability to grade seedlings because they cannot be removed from the containers with intact rootballs.

HARDENING

Spring and summer sown greenhouse crops are hardened, as well as overwintered, in shadehouses at the nursery. Actively growing aspen must be moved to shadehouses by early August in the Fort Collins area. Crops moved to shadehouses late August do not complete terminal bud development and have high mortality the following spring.

At the start of the hardening period, excess nutrients are leached from the containers and the seedlings are mildly drought stressed. The fertilizer is changed from high N/PK plus micronutrients to low N/PK plus micronutrients. Containers should be kept up off the ground until fall to allow adequate air pruning of the roots. Deer fencing around those areas of the shadehouses storing aspen is also necessary at the nursery.

Height growth of the spring 1984 crop (fig. 3), which was moved to the shadehouse July 3, 1984, stopped after 4 to 5 weeks in the shadehouse. Final mean height was 68 cm. Extensive root system development followed. Caliper growth continued into October at which time the leaves turned color and abscised normally. Mean caliper in

Figure 4.--Quaking aspen seedlings in Colorado Styro-Blocks at the end of the exponential growth phase. Average seedling height is 55 cm.

October was 5.54 mm. Lateral and terminal bud development were excellent. Overwintering mortality was less than 1 percent.

TOP PRUNING

Top pruning at the beginning of the shadehouse hardening period was tested as a means to stop height growth quickly and improve caliper development relative to unpruned seedlings. Results were the opposite. Eighteen Styro-Blocks of seedlings from the spring 1984 crop were pruned 2 days after being moved to the shadehouse (July 5, 1984) for comparison with the rest of the crop (692 unpruned Styro-Blocks). Average height was 57 cm prior to pruning and 27 cm after pruning. Average caliper of both groups was 3.9 mm at the time of pruning. Pruning induced lateral bud break and the pruned seedlings continued to put on top growth 2 weeks longer than the rest of the crop, thus delaying the hardening process. The caliper of the pruned seedlings 21 weeks after sowing (October 1, 1984) averaged 4.6 mm. This was significantly (t-test, $p = .05$) less than the caliper of the rest of the crop which averaged 5.5 mm at that time (fig. 3). If top pruning is necessary to reduce seedling height, it should be done after the seedlings are dormant.

Height reduction is best accomplished by shortening the period of time for accelerated greenhouse growth. The spring 1984 crop (fig. 3) was grown in the greenhouse for 61 days and reached a final average height of 68 cm. A crop sown in the summer of 1984 was grown in the greenhouse for 51 days and reached a final average height of 50 cm (fig. 5). Both crops were shadehouse hardened and had very similar height growth curves for the first 51 days. The 10-day difference in the growing period results in a substantial difference in final height because of the 1.5 cm per day height growth rate during the exponential phase.

GRADING

Grading is most efficiently done in the shadehouse after leaf abscission. The seedlings are easily handled and inspected then and the large majority of the season's root growth has occurred. Three criteria are used in grading. First, the seedling must be healthy. Second, the stem must be straight and upright, and within a fairly broad height range dependent upon the particular crop. Third, the root system must be extensive enough to permit intact removal of the seedling from the Styro-Block. Grading on the basis of caliper is infrequent because seedlings with poor caliper development also usually have poor stem form and inadequate root systems.

The number of seedlings that make grade is approximately 50 percent of the total cavities sown. Mortality is only 5.3 percent at the end

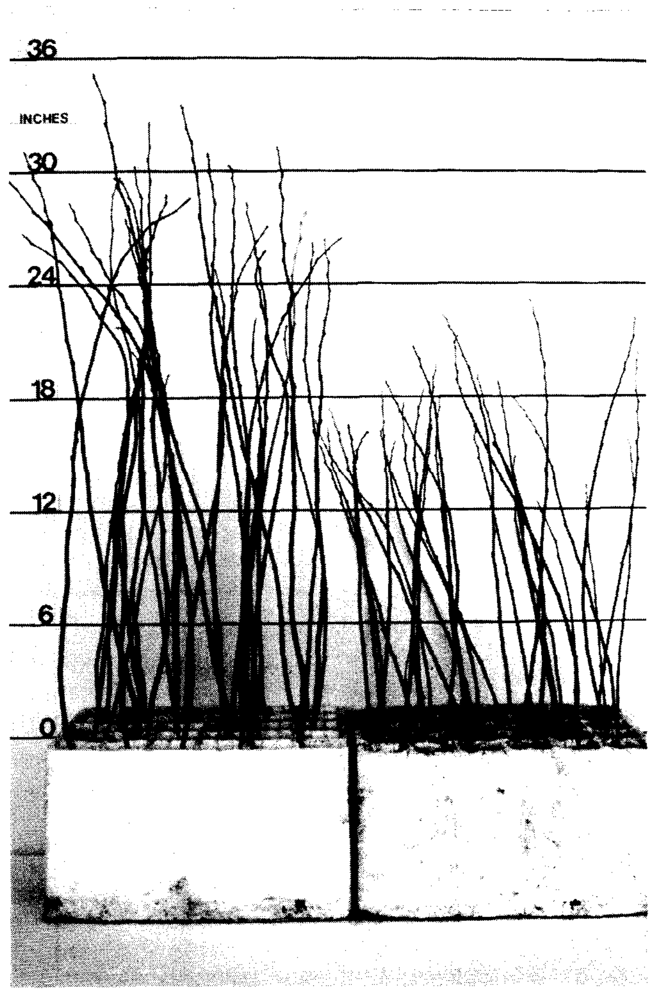

Figure 5.--Graded, dormant quaking aspen seedlings from the spring 1984 crop (left) and a summer 1984 crop (right). The hardening process was begun 61 days after sowing the spring crop and 51 days after sowing the summer crop.

of the exponential phase (see Transplanting tabulation). Thus nearly 45 percent of the cavities sown contain living seedlings at that time which will not make grade. The 45 percent cull rate is the result of seedling variability. To illustrate this, all 30 seedlings in a randomly selected Styro-Block from a crop 2 weeks into the hardening period were measured and ordered by height (fig. 6). Only the tallest 15 seedlings had sufficient caliper to remain upright without support from adjacent seedlings. The next 6 smaller seedlings had poor stem form and were being partially shaded and completely supported by adjacent seedlings. The smallest 9 seedlings, one of which had died (d), were completely shaded by taller seedlings and were growing intertwined among them or on the surface of the Styro-Block. Only the large dominant seedlings make grade at the end of the hardening period.

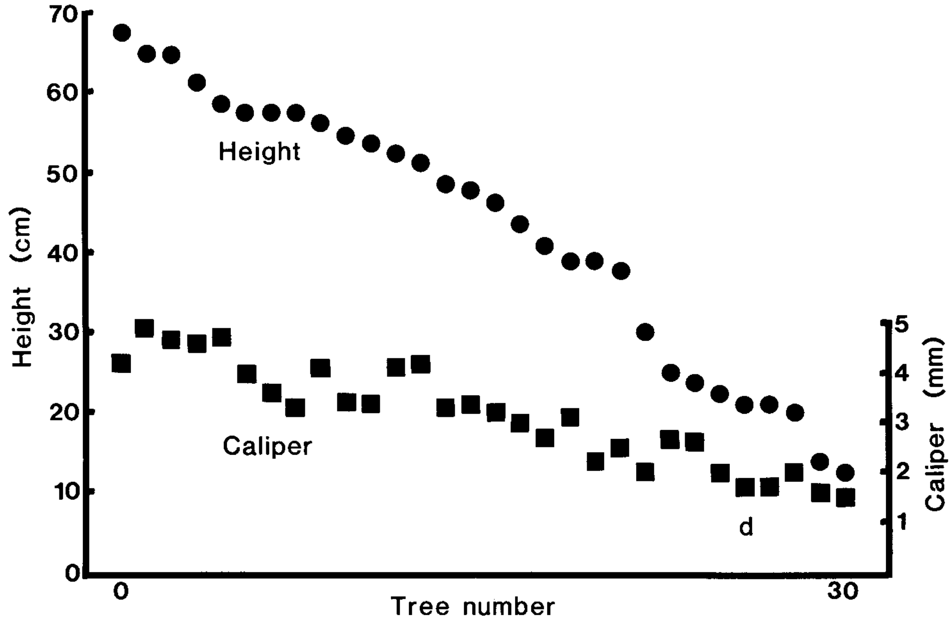

Figure 6.--Variability in seedling height and caliper two weeks into the hardening period within a single Styro-Block of 30 seedlings. One of the 30 was dead (d).

A method for producing a more uniform crop has yet to be developed. Slowing the growth rate by moving established seedlings from the greenhouse to the shadehouse for the majority of the exponential growth phase is being considered. Sorting the seedlings by size when 20 to 30 cm tall to reduce the competition should decrease the cull rate substantially. However, Styro-Blocks, being single 30-cavity units, are not amenable to this, and the seedlings cannot be removed from the blocks with intact rootballs until well into the hardening period.

WINTER CROPS

The growth of winter aspen crops can be as unpredictable as the weather. Growth rates are slower, relative to spring and summer crops, due to the shorter day length and lower light intensities. However, extremely slow rates are possible. The height growth of the winter 1984 crop (fig. 7), sown December 3, 1984, was similar to that of the spring 1984 crop (fig. 2) during the first 3 weeks following sowing. But the exponential growth phases of the two crops are drastically different. Ten weeks after sowing, the winter 1984 crop averaged only 10 cm tall while the spring 1984 crop averaged 60 cm tall. The weather during weeks 3 through 10 of the winter crop was unusually cloudy and the sharp increase in growth after the tenth week was associated with a concurrent improvement in the weather.

Such extreme variability in growth rates can cause scheduling problems. The extension of the time required for the exponential phase can re

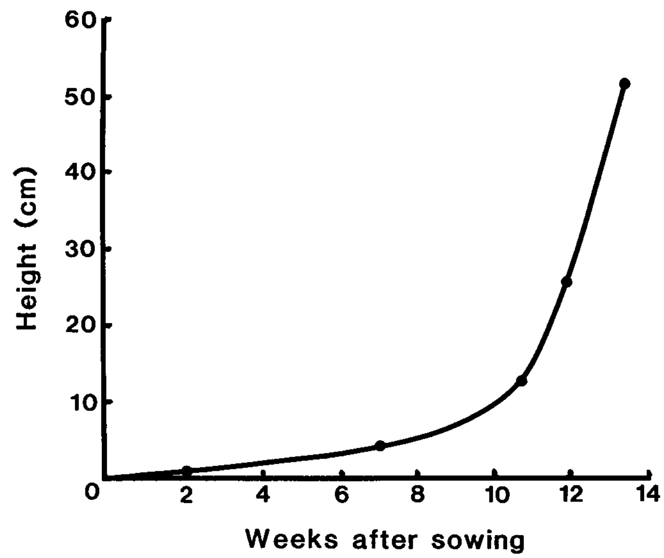

Figure 7.--Height growth, from sowing through the exponential growth phase of the winter 1984 crop of quaking aspen seedlings sown December 3, 1984.

suit in a crop of the desired height but for which there is no time remaining for the greenhouse hardening. The uncertainty of winter crops can be avoided without reducing the total number of seedlings produced by growing two crops during the spring and summer months. With a maximum of 8 weeks greenhouse time required per spring crop, two crops can easily be grown in succession in time to begin shadehouse hardening by August 1.

LITERATURE CITED

Benson, M. K. and M. L. Harder. 1972. Storage of aspen seed. Genet, Physiol. Note No. 11. p. 1-4.

Fechner, G. H., K. E. Burr, and J. F. Myers, 1981. Effects of storage, temperature, and moisture stress on seed germination and early seedling development of trembling aspen. Can. J. For. Res. 11:718-722.

Fisher, J. T. and G. A. Fancher. 1984. Effects of soil amendments on aspen seedling production. In The challenge of producing native plants for the Intermountain area. Proc. Intermountain Nurseryman's Assoc. 1983 conference. Las Vegas, NV. Aug. 8-11, 1983. USDA Forest Service Gen. Tech. Rep. INT-168, 96 p.

McDonough, W. T. 1979. Quaking aspen--seed germination and early seedling growth. USDA Forest Service Res. Pap. INT-234, 13 p.

Okafo, 0. A. and J. W. Hanover. 1978. Comparative root and shoot development of trembling and bigtooth aspen seedlings. p. 334-346. In Proc. Fifth North Amer. Forest Biology Workshop, Gainesville, FL. Mar. 13-15, 1978.

Roe, E. I. and D. P. McCain. 1962. A quick method of collecting and cleaning aspen seed. Tree Planters' Notes 51:17-18.

U.S. Department of Agriculture, Forest Service. 1974. Seeds of woody plants in the United States. Agric. Handb. No. 450. Shopmeyer, C. S., tech. coord. Washington, DC. USDA Forest Service, 1974. 883 p.

Wang, B. S. P. 1973. Collecting, processing, and storing tree seed for research use. Proc. IUFRO Int. Symp. Seed Processing. Bergen, Norway. Vol. I. Paper 17.

Williams, B. D. and R. S. Johnston. 1984 Natural establishment of aspen from seed on a phosphate mine dump. J. Range Mgmt. 37:521-522.