IMPACTS OF NURSERY PROCESSING ON THE SURVIVAL AND GROWTH OF 2+0 DOUGLAS-FIR SEEDLINGS

----Robyn L. Darbyshire

ABSTRACT: Three handling treatments compared seedlings during the time period from just before lifting to the time when seedlings are placed in nursery cold storage after grading and packing. The handling treatments were as follows: (1) the indoors treatment--"conventional" nursery handling with seedlings held for 48 hours in a cool, humid room between lifting and grading; (2) the outdoors treatment--"conventional" nursery handling with seedlings held outdoors on a covered dock for 48 hours between lifting and grading; and (3) bedpacking, where seedlings are lifted and taken directly to cold storage without the extra handling involved in grading and packing.

Bedpacked trees had the lowest plant moisture stress (PMS) and temperature during the holding period. There was no difference in PMS for the indoors and outdoors treatments, but the indoors treatment did keep the seedlings at a lower temperature than the outdoors treatment.

Planted seedlings showed no significant differences in budbreak or survival due to handling treatment after one growing season, but bedpack seedlings had a significantly longer ($p=0.01$) new leader and new leader dry weight than the other two treatments. Though not significant, the same trend occurred for dry weight of new laterals and total shoot dry weight at the end of the first year. The length of new terminal growth was measured for the second and third growing seasons and showed no significant differences between treatments.

More work at different nurseries and in different outplanting environments is needed before strong recommendations can be made about bedpacking versus conventional handling. Greater attention to the management of temperature and plant moisture stress during nursery handling may eliminate differences between conventional handling and bedpacking.

Paper presented at combined meeting of the Western Forest Nursery Council and Intermountain Nurseryman's Association, Coeur d'Alene, ID, August 14-16, 1984.

Robyn L. Darbyshire is Research Assistant, Nursery Technology Cooperative, Oregon State University, Corvallis, Oregon.

INTRODUCTION

This project studied the seedling production process from the time just before undercutting in the nursery bed to the time that graded seedlings are placed in nursery cold storage. This is a period in nursery seedling production when most of the physical handling of seedlings occurs. During this time, seedlings may experience not only physical abuse, but also water and temperature stress. Temperature and plant moisture stress (PMS) can be monitored to prevent damage, but there are currently no methods of quantifying or monitoring physical abuse.

Differences in seedling handling that may cause differences in plantation performance can be very subtle, yet produce rather pronounced effects. Mullin (1974) studied a red pine (Pinus resinosa) plantation in Ontario, Canada, for 20 years. This plantation was established for a study that compared two planting crews, two types of packaging, and different lengths of unrefrigerated storage. He found that it took 20 years for a difference in planting crews to be significant. This difference amounted to a 14% greater volume per acre for one of the crews, and was due to a difference in handling, not a difference in survival. After one year, it was apparent that trees held for a longer period in unrefrigerated storage had lower survival. After five years, height growth was also significantly affected by the length of the unrefrigerated storage.

Albert and others (1980) looked at the effect of packing on radiata pine (Pins radiata). They broke down the packing/shipping process into five steps: (1) lifting; (2) transporting to the packing shed; (3) grading and packing seedlings into boxes; (4) packing boxes into crates for shipping; and (5) transferring seedlings to planting bags at the planting site. The growth and survival of seedlings removed from the process after completing (1), (1) through (4), and (1) through (5) was compared. First-year mortality increased from 0.6% if removed after (1) to 1.6% after (4) to 7% if removed after (5). Mean height after one year decreased from 71 cm if removed after (1) to 50 cm after (5). Thirdyear results maintained these differences and also showed a decrease in caliper from 28 mm after (1) to 21 mm after (5). Values for height and caliper for trees removed after (4) were about midway between the mentioned figures.

Trewin (1978) also looked at radiata pine in terms of reducing damage by eliminating steps in

the handling process. A system was devised where seedlings are lifted directly into boxes that also serve as tree planting "bags". The result has been greater survival and growth.

The two studies cited here on radiata pine show that the handling of seedlings at the nursery plays a role in decreasing the ability of a seedling to grow vigorously after outplanting. These studies and that of Mullin also show that handling after the seedlings leave the nursery is also important in this respect.

Another relatively new idea in stock handling is the inclusion of a "pre-processing cooler" in packing sheds. The D. L. Phipps State Forest Nursery near Elkton, Oregon, has a pre-processing cooler--a separate room for holding the unprocessed seedlings between lifting and grading.
The temperature is maintained at about 40 degrees F and the relative humidity is kept between 80 and 90%. Before the new facility was built, the unprocessed seedlings were held outside on a covered dock. The pre-processing cooler offers a possible improvement by keeping the seedlings at a fairly constant temperature in a high humidity environment.

The differences between seedlings packed in a packing shed and seedlings packed at the nursery bed have not been studied for Douglas-fir, nor has a comparison been made of seedlings stored outdoors between lifting and grading and seedlings stored during this same time in a facility that maintains a fairly constant cool temperature and high humidity. Answering these questions could be important in determining the design of future seedling processing facilities, as well as in improving the physiological condition of outplanted seedlings.

OBJECTIVES

The objectives of this study were as follows:

1. To characterize the temperature and the plant moisture stress of bare-root stock in the time period from just before lifting until the seedlings are placed in nursery cold storage.

2 To compare growth and survival of trees handled in three different ways at the nursery:

   A. Trees handled conventionally with the use of a pre-processing cooler to hold stock between lifting and grading. (The "indoors" treatment.)

   B. Trees handled conventionally, but stored outdoors between lifting and grading. (The "outdoors" treatment.)

   C. Bedpacking.

PROCEDURES

The seedlings used for this study were from a 2500 foot elevation in seed zone 072. They were lifted at the D. L. Phipps State Forest Nursery in Elkton, Oregoti, in February of 1981. A diagram of the handling and planting is shown in Figure 1. This process was repeated on 4, 10, and 25 February 1981. Seedling temperature and PMS were monitored during the handling process at the steps shown in Figure 2. PMS was monitored with a pressure chamber (PMS Instrument Company) and temperature was monitored with an eight-inch-long stem dial thermometer (Weston Co., calibrated from 25 to 125 degrees F).

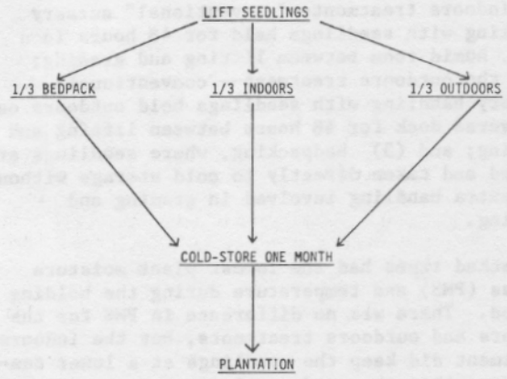

Figure 1.--A diagram of the experimental procedure. This was repeated on 4, 10, and 25 February 1981.

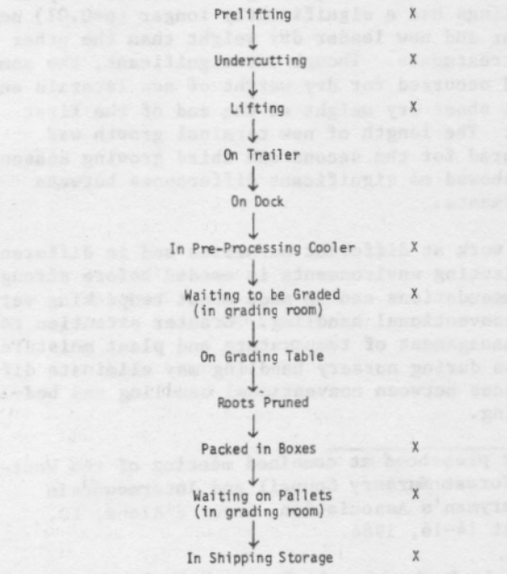

Figure 2.--Steps in nursery handling at the D. L. Phipps Nursery. An "X" indicates steps where monitoring of PMS and temperature occurred for this study.

Undercutting occurred if PMS was greater than 10 bars. The seedlings were lifted into plastic tubs (for the indoors and the outdoors treatments) or cardboard shipping boxes (for the bedpack treatment) 1 1/2 hours after undercutting. The trees were then delivered to their respective holding places. Forty-eight hours later, the seedlings from the indoors and the outdoors treatments were brought into the grading room for a 20-minute delay before grading. The seedlings were graded by nursery graders to a minimum 3-mm caliper and 6-inch shoot length. They were bundled in groups of 50 before being root-pruned to 9 inches. Seedlings were then packed in boxes and placed in cold storage. The bedpack seedlings were graded and root-pruned at the time of planting.

The outplanting site was planted in a split-plot design with four replications. Whole plots were lifting dates and sub-plots were handling treatments. Fifty trees were planted per plot for a total of 1800 trees. Trees were planted on a 2 x 2 foot spacing on a slightly east-facing aspect. The site was a former grassy field in the McDonald State Forest. The site was plowed about one month before planting. The seedlings were planted with a shovel, and all trees were planted by the same person.

Initial morphology was determined for each lifting date and handling treatment combination. Height growth, budbreak, survival, and morphology at the end of the first growing season were measured. Height growth was subsequently remeasured at the end of the second and third growing seasons.

KESULTS AND DISCUSSION

Plant Moisture Stress During Handling

Guidelines for interpreting PMS of nursery seedlings have been established by Daniels (1979) and Cleary (personal communication). It is generally recommended that PMS be kept less than 5 bars at all times between undercutting and planting.

A comparison of the PMS results is shown in Figure 3. For all treatments, PMS tended only to decline after undercutting. The reason why PMS declined for the indoors and the outdoors treatments on the first lifting date and then started to increase again, peaking at about six to eight hours after undercutting, is unknown. The increase in PMS after grading for the first lifting date may be due to a more gradual drying-out over the 48-hour holding period than to drying during the grading itself. The monitoring for this study was not intensive enough during grading to determine what, if any, drying occurs during grading. The increase in PMS for the indoors treatment during the third lifting date occurred as the seedlings dried out after being watered and serves as an illustration that water loss can occur in the pre-processing cooler.

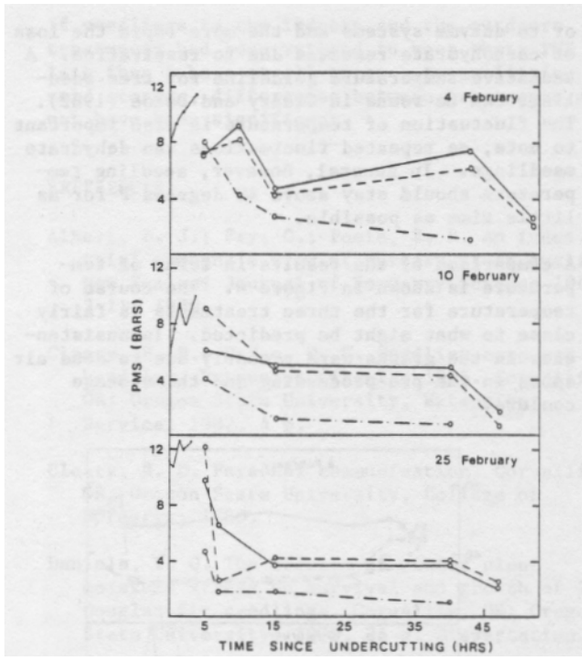

Figure 3.--Seedling Douglas-fir PMS with time for the three handling treatments: indoors ------, Outdoors_____ bedpack -.-.-.-.-. The solid line with the filled circles represents the time before the treatments were separated. Each point is the mean of three to four seedlings.

It is interesting to note the similar PMS measurements for the indoors and the outdoors treatments. However, fog often is present until 11 a.m. or noon in this part of Oregon, and this may be the reason for similarity. For nurseries in drier climates (i.e. the east side of the Cascades) there may indeed be a difference in PMS between these two types of handling.

The most rapid decline in PMS for all treatments occurs once they are placed in the shipping boxes. A relative humidity of close to 100% inside the boxes is probably partly responsible for this decline. For the indoors and the outdoors seedlings, the rate of PMS decline was much slower versus the rate of PMS decline for the bedpack seedlings. This study was not designed to investigate this particular question, but these results do suggest that the indoors and the outdoors seedlings have lost some of their capacity to internally adjust their PMS, perhaps due to lower moisture content after 48 hours of holding in an environment that allows water loss from the seedling.

Temperature During Handling

Temperature guidelines for seedling handling are based on general biochemical knowledge of the effect of temperature on essential plant enzyme systems (i.e. the enzyme systems of photosynthesis and respiration). Length of time at a certain temperature is important too, as the longer the time at an unfavorably high temperature, the greater the risk of incurring damage to tissues

or to enzyme systems and the more rapid the loss of carbohydrate reserves due to respiration. A tentative temperature guideline for tree seedlings can be found in Cleary and DeYoe (1982). The fluctuation of temperature is also important to note, as repeated fluctuations can dehydrate seedlings. In general, however, seedling temperature should stay above 40 degrees F for as little time as possible.

A comparison of the results in terms of temperature is shown in Figure 4. The course of temperature for the three treatments is fairly close to what might be predicted. Inconsistencies in the graphs were probably due to dead air spots in the pre-processing and the storage coolers.

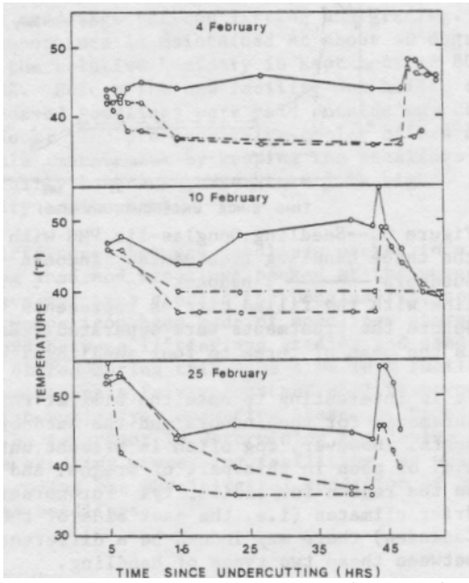

Figure 4.--Temperature of Douglas-fir seedlings with time for the handling treatments: indoors --------, outdoors_____ , bedpack-.-.-.-.-. Each point is the temperature of one box or tub of seedlings.

The most important differences in temperature occurred at the time of packing, about 45 hours after undercutting. The temperature inside the box tends to rise due to warm air (55-62 degrees F) being "packed" in with the seedlings. The indoors treatment, however, tended to have a higher absolute temperature increase versus the outdoors treatment, as the indoors trees are cooler to start with. This lower initial temperature may also cause the indoors seedlings to reach room temperature more rapidly if they are left at a warmer temperature for a longer period of time (i.e. if they spend a longer time in the grading room before being packed).

Initial Morphology

Overall, caliper averaged 4.7 mm, the average shoot length was 36.8 cm, shoot dry weight averaged 4.5 g, the average root length was 31.1 cm, and root dry weight averaged 2.4 g. These seedlings were well above the minimum grading standards of 3 mm caliper and 15.2 cm shoot length.

Budbreak

All seedlings burst their buds. An analysis of days to 50% budbreak showed no difference between treatments.

Survival

First-year survival was high--mortality was due primarily to rabbits. Maximum mortality in any row due to causes other than rabbits was 6%. There was no appreciable decrease in survival in the second through fourth growing seasons.

First-Year Growth

The analysis of variance showed the length and the weight of the new terminal growth to have been significantly affected by the handling treatment ($p=0.01$) (see Table 1). When the treatment means were compared using Fisher's LSD (Ott 1977), the bedpack trees were found to have a longer new terminal (6.9 cm vs 6.1 cm) and a heavier new terminal (0.51 g vs 0.41 g). The treatment means for the indoors and the outdoors treatments were not significantly different. The results were the same when initial height was used as a covariate to help account for the initial differences in size.

Table 1.--Treatment means for Douglas-fir seedlings in the plantation study. For a given dependent variable, means followed by the same letter are not significantly different at p-0.01. Each mean is the average of 120 seedlings. Treatment means are unadjusted for initial height.

DEPENDENT VARIABLE	TREATMENT INDOORS	OUTDOORS	BEDPACK
CALIPER (mm)	6.0	6.0	6.2
2+0 SHOOT WEIGHT (g)	5.75	5.55	6.16
NEW TERMINAL LENGTH (cm)	6.2 a	6.0 a	6.9 b
NEW TERMINAL WEIGHT (g)	0.42 a	0.41 a	0.51 b
NEW LATERAL WEIGHT (g)	2.72	2.55	3.07
TOTAL SHOOT WEIGHT (g)	8.89	8.51	9.74
NEW LATERAL PLUS NEW TERMINAL WEIGHT (g)	3.15	2.96	3.58

Even though treatment was not significant for the other growth measurements in Table 1, a trend is evident--the bedpack seedlings tended to be larger at the end of the first growing season, even when initial height was used as a covariate. The next largest seedlings were from the indoors treatment, and the smallest were from the outdoors treatment, but the difference between the indoors and the outdoors treatments was small.

Second- and Third-Year Growth

The length of the new terminal was measured in 1984 for the 1982 and 1983 growing seasons. The analysis of variance showed no significant differences between treatments. Mean height for all treatments in 1982 was 8.6 cm and in 1983 was 19.5 cm.

CONCLUSIONS

1. There were no significant differences between the indoors and the outdoors treatments. This may not be the case at a nursery in a drier climate. The high relative humidity and the fog at Elkton during lifting probably helped to minimize any growth differences between these two treatments due to plant moisture stress. Also, daytime temperatures outdoors were not over 60 degrees F during the experimental lifting, and seedlings did not remain at this temperature for a very long period of time (Fig. 4). Severe freezing temperatures at night also did not occur. This does not mean that the pre-processing cooler is not needed at Elkton, as warmer, drier lifting years have been known to occur. The fact that the pre-processing cooler is there and the knowledge that it is there for seedling protection will possibly promote better handling by nursery employees because they are more aware of the need for care and attention to detail in seedling handling.

2. Bedpacking may result in more seedling growth. Treatment differences may become even more accentuated after several growing seasons. Why might these differences occur? Certainly there is less handling involved and the bedpack seedlings are also exposed to less temperature and plant moisture stress prior to planting. New terminal length in the first growing season was significant, but not in the second or third growing seasons. Total height may be a more appropriate variable for subsequent growing seasons. A longer term study and other changes in nursery practice would be required before bedpacking is used operationally, but its use may result in better seedling growth.

3. More severe environmental conditions on the planting site may have emphasized handling treatment differences more. The seedlings planted in the plowed field were not subjected to much water stress (maximum pre-dawn PMS was 8 bars) and more stress may have provided larger differences between treatments. A site with moderate competition may provide a better environment to show early differences.

4. Attention to factors during handling that affect temperature and plant moisture stress is important in preventing possible damage. Control of temperature and plant moisture stress will help produce the best quality seedlings possible and may decrease any differences between bedpacking and conventional handling. For example, the lifting conditions for this study allowed PMS levels to occur that, according to PMS guidelines, should have been alleviated by watering. If seedlings in the indoors and the outdoors treatments had been watered to keep their PMS less than 5 bars at all times between lifting and cold storage, differences between treatments may not have been significant.

REFERENCES

Albert, D. J.; Fry, G.; Poole, B. R. An industrial company's view of nursery stock quality. New Zealand Journal of Forestry Science 10(1): 2-11; 1980.

Cleary, B. D.; DeYoe, D. R. Seedling care and handling. Extension Circular 1095. Corvallis, OR: Oregon State University, Extension Service; 1982. 4 p.

Cleary, B. D. Personal communication. Corvallis, OR: Oregon State University, College of Forestry; 1980.

Daniels, T. G. The effects of winter plant moisture stress on survival and growth of 2+0 Douglas-fir seedlings. Corvallis, OR: Oregon State University; 1979. 86 p. Dissertation.

Mullin, R. E. Some planting effects still significant after 20 years. Forestry Chronicle 50 (5): 191-193; 1974.

Ott, L. An introduction to statistical methods and data analysis. North Scituate, MA: Duxbury Press; 1977. 730 p.

Trewin, A. Pine seedlings--handle with care! What's New in Forest Research, No. 67. Rotorua, New Zealand: Forest Research Institute; 1978. 4 p.