Size and Survival
of 2-0 Douglas-Fir Seedlings

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INTRODUCTION

Results reported here are from a large study designed to evaluate the effects of certain nursery procedures on subsequent survival of Douglas-fir seedlings. The effects of storage conditions and lifting dates were reported elsewhere (9).

The determination of the optimum size of seedling for planting on different sites has been the concern of foresters for many years (3, 6, 7, 8). Recently, Christmas-tree growers in the Pacific Northwest have planted Douglas-fir seedlings extensively and, like foresters, have shown interest in obtaining high survival at minimum cost. They often demand large seedlings. Nurserymen strive to produce adequate numbers of seedlings that meet desired size requirements and that can still be easily lifted, packed, stored, and shipped. A compromise is often made between the size of seedling wanted by foresters and other users and the size of seedling that is easy or even possible for the nurseryman to produce. Seedling size is of considerable interest to nurserymen, foresters, and other users.

Foresters offer various reasons for poor survival of outplanted nursery stock, one being that seedlings supplied by nurseries are too small. Christmas-tree growers likewise complain that small seedlings do poorly. Published information both supports and refutes these claims because conditions vary on the plantation sites, and site is an important consideration in determining seedling survival. Although on some sites small seedlings may not survive well, on other sites they may prove satisfactory (1). Nursery conditions, date of lifting, and storage conditions for seedlings further confound the situation.

MATERIALS AND METHODS

The seed source was zone 252 (Willamette Valley). Seedlings were grown at the Dwight L. Phipps State Forest Nursery at Elkton, Oregon under routine nursery practices. After the second growing season (seedlings classed 2-0), seedlings were lifted on four different dates: November 19, 1970; January 25, February 22, and March 15, 1971. At each lifting, seedlings were packed and transported to Corvallis on the same day. Some trees were planted immediately and others were stored for 3, 6, or 9 weeks at 35 F, then processed for planting.

Before planting, each seedling was washed, its dead branches were removed, and excess surface water was removed by blotting. The seedling was then weighed to the nearest 0.1 gram. Care was taken to keep the roots moist at all times. Each seedling was assigned a number that was put on a paper tag attached with string. Seedlings from each treatment were divided into four equal lots, with fifty seedlings in each lot. Two lots were planted in blocks on each of two planting sites. Block location within each site was predetermined randomly. One site was located on a low ridge at an elevation of 127 m (425 ft) and was ploughed before planting. It was kept free from all vegetation except the planted trees and was designated the bare site. The second site was a nearby grassy field at about the same elevation approximately one-quarter mile away on a gentle north slope. This site was designated the grassy site and offered competition from a variety of grasses and forbs. This field had been cultivated previously but had been in grass for at least 5 years. Measurements of plant moisture stress were made with a pressure-chamber apparatus during the late spring and summer after planting.

Seedlings were evaluated as alive or dead in the October following planting. A total of 9,600 seedlings were weighed and outplanted. A few seedlings could not be located; some were lost in the grass and others were destroyed by animals. No more than three of the fifty seedlings in any one block were lost, however. A total of 9,531 were found and evaluated, and these form the basis of this report.

RESULTS AND DISCUSSION

The size (fresh weight) distribution of all seedlings measured is shown in Figure 1. This kind of distribution (approximating a Poisson curve) can be expected from cultivated crops grown in dense, even-aged stands. The cumulative percent curve (Figure 1) enables one to visualize easily the proportion of seedlings above or below a given seedling weight. For example, about one-fourth of the seedlings weighed less than 4 grams and about one-fourth weighed more than 12 grams. The median seedling weighed about 7 grams. Figure 2 is a photograph of ten typical seedlings that weighed 4.5 to 5.5 grams.

Figure 3 shows the relation between shoot length and total fresh weight and between stem diameter and total fresh weight. The average 4-gram seedling had a crown height of 12.2 cm (about 5 inches), and a stem diameter of about 2.6 mm (about 0.1 inch).

Figure 4 shows the percent of survival on the two planting sites for seedlings of each weight class. Survival was higher on the bare site than on the grassy site (difference significant at the 99 percent confidence level). Seedlings growing on the grassy site were under higher moisture stress than seedlings growing on the bare site. In mid-August the minimum (pre-dawn) plant moisture stress was 47 atmospheres on the grassy site but only 15 atmospheres on the bare site (average of 96 measurements). Competition on the grassy site reduced survival in all sizes of seedlings, but the smallest seedlings suffered the highest mortality.

Overall, survival was nearly the same on both sites for seedlings planted in November. Percent of survival for seedlings planted later on the grassy site was lower, but percent of survival on the bare site was slightly higher than that for November plantings (Table 1). Seedlings weighing less than 4 grams suffered greater mortality on both planting sites than seedlings weighing 4 grams or more (shoot height 5 inches).

Results of a field experiment including different lifting dates are somewhat difficult to interpret because of seasonal changes and physiological changes in planting stock during the experiment. For example, seedlings lifted in January will probably be planted under more favorable conditions, because of seasonal changes, than those lifted in March or April. Survival data for stock planted early are not comparable with survival data obtained for stock lifted late because of the natural changes of season. To help interpret data in the present study, some seedlings from each lot were planted in metal cans and grown for 1 month in a growth room under favorable conditions (photoperiod 16 hours, 75–65 F temperature). Survival data from that experiment agreed in general with the survival data from the bare site in this experiment, which indicates that the date of planting did not play an important role in determining survival. Survival reported here appears to depend upon seedling physiology and planting site rather than date of planting.

The large difference in survival between the two sites emphasizes the importance of considering site when selecting planting stock. A site with vegetative competition is apparently not the place to plant seedlings that are lifted late in the season, especially if storage is necessary (9). But the same stock planted on a bare site, such as a plowed field, may survive satisfactorily.

Table 1 shows that an advantage in survival can be gained by culling seedlings smaller than 4 grams. In this experiment, such culling would mean discarding about one-fourth of the seedlings. (An alternative to this heavy cull rate is to grow seedlings at a lower seedbed density in the nursery so that fewer small seedlings are produced. In such a population the smallest seedlings would still be spindly and weak and might not survive well under adverse conditions, even though they might weigh more than 4 grams.) For a population of seedlings like the one in this experiment, it would seem wise to discard seedlings smaller than 4 grams. Probably the smallest seedlings in any population should be discarded. Even though small seedlings may survive when planted on sites free from vegetative competition, they cannot be expected to grow as rapidly as larger seedlings, and they will probably never "catch up" with larger seedlings on the same site (2, 4). For Christmas-tree growers, small seedlings may survive satisfactorily, but the time from planting to harvest will be greater than for larger seedlings.

The cull point, or seedling weight below which survival would decrease, for seedlings in this study appeared to be about 4 grams (shoot length 5 inches). Other years or different

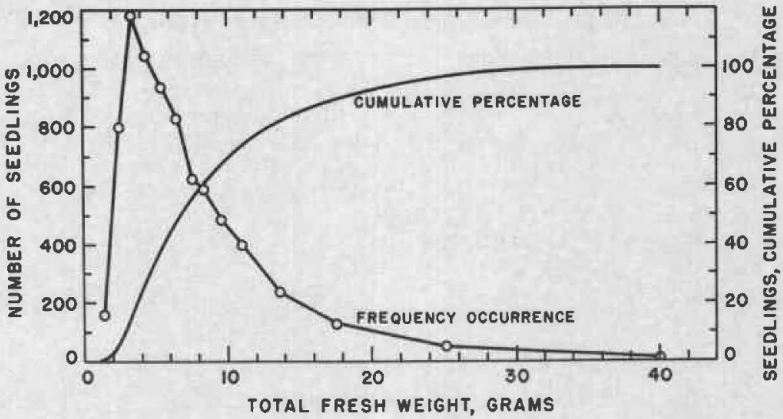

Figure 1. Size distribution of the Douglas-fir seedlings tested. About one-fourth weighed less than 4 grams (shoot length about 5 inches) and about one-fourth weighed more than 12 grams.

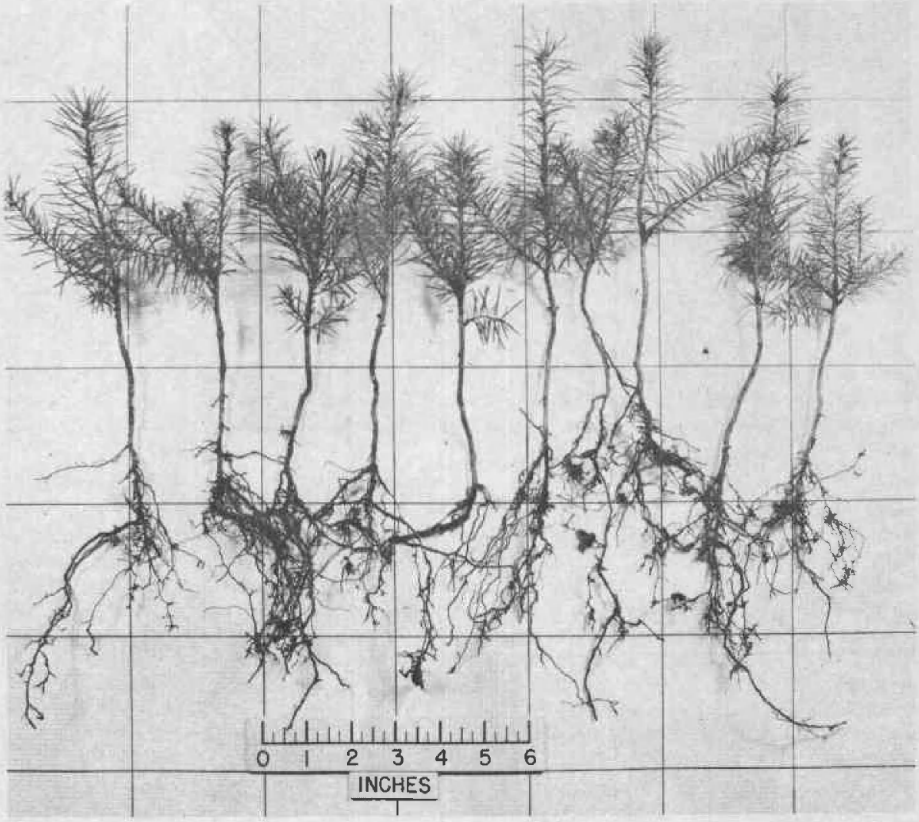

Figure 2. Typical Douglas-fir seedlings with total fresh weights between 4.5 and 5.5 grams.

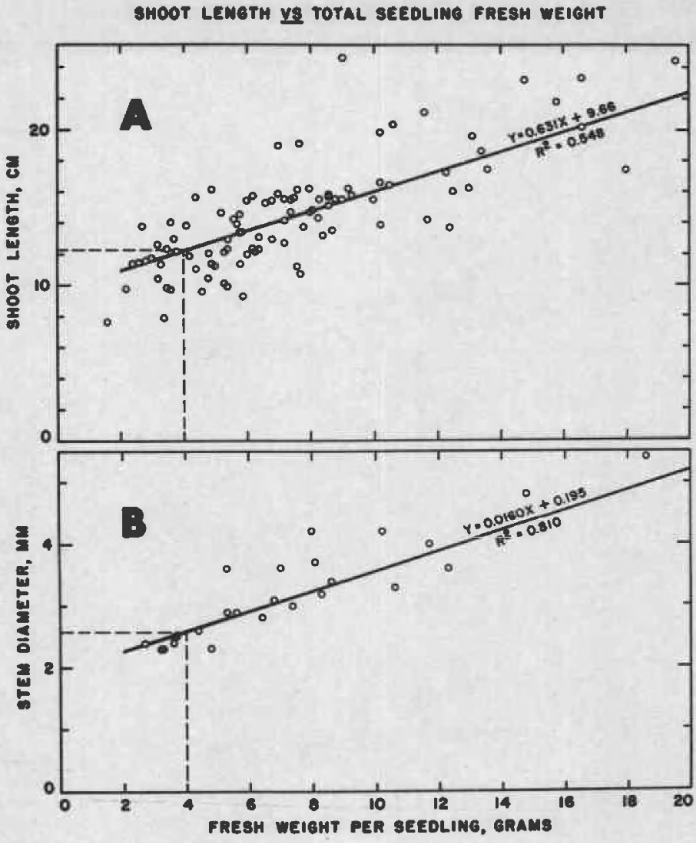

Figure 3. Regression of shoot length on total seedling fresh weight (A). A seedling weighing 4 grams had a shoot length of about 12.2 cm, or about 5 inches. Regression of stem diameter on total seedling fresh weight (B). A seedling weighing 4 grams had a stem diameter of about 2.6 mm, or about 0.1 inch.

nursery conditions could produce slightly different results. That is, the desirable cull point could be above (probably not below) 4 grams. The ability of seedlings to grow cannot be inferred from their ability to survive. There is some evidence (Michael Newton, Forest Research Laboratory, Oregon State Univ., Corvallis, personal communication, 1976) suggesting that plant moisture stress may be less in large seedlings than in small ones. The high cost of labor for planting, compared with cost of seedlings, provides economic incentive for not planting small seedlings. For these reasons, it is desirable to avoid planting small seedlings if at all possible, even on the most favorable planting sites. It would seem prudent to discard seedlings smaller than 4 grams fresh weight, and in some instances, even larger minimum sizes should be required. The seedlings shown in Figure 2 (4.5–5.5 grams) are the smallest size that we recommend for planting.

Consideration of the minimum size of seedlings that is acceptable is only one of many that must be taken into account by the regeneration forester. We have not discussed seedling production or planting costs in this study, but these and other factors must certainly influence the forester's decision when he places an order for planting stock.

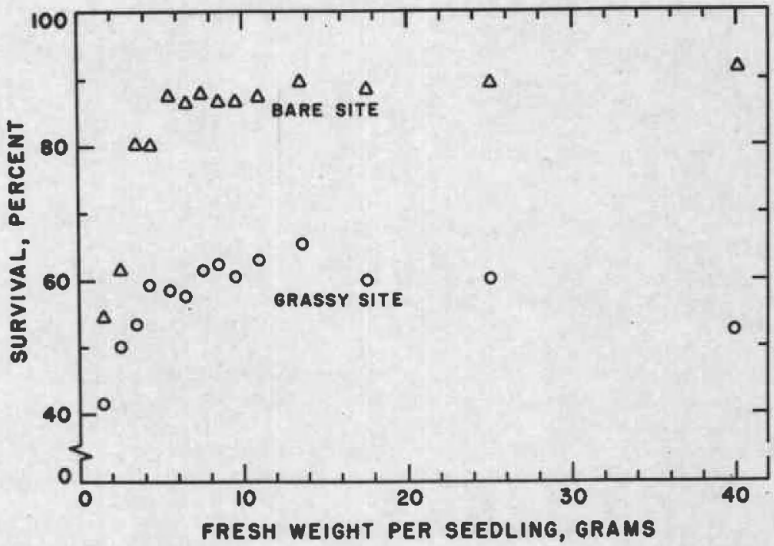

Figure 4. Survival by size of seedling planted on a bare site and on a grassy site. Seedlings weighing less than about 4 grams suffered higher mortality than larger seedlings.

Table 1. Percent of Survival of Seedlings Planted on a Bare and a Grassy Site after Four Lifting Dates.

Seedling weight	Lifting date				Total
	November	January	February	March	
	%	%	%	%	%
			GRASSY SITE		
Less than 4 grams	68.1	59.2	49.8	30.7	50.9
4 grams or more	82.8	73.6	53.0	42.2	60.0
All seedlings	79.2	70.0	52.2	39.8	57.9
			BARE SITE		
Less than 4 grams	74.2	73.4	76.9	83.6	77.2
4 grams or more	83.6	85.4	85.4	89.2	86.2
All seedlings	81.4	82.7	83.6	88.2	84.3

SUMMARY

Seedlings 2 years old (2-0), grown at the Dwight L. Phipps State Forest Nursery, Elkton, Oregon, were lifted on four different dates, weighed, and planted on a grassy site and on a bare site. Best survival was obtained on the bare site for all lifting dates. The smallest seedlings survived poorly on both sites, and increase in overall survival could be obtained by discarding them. The minimum acceptable size of seedling may vary from one population of seedlings to the next, but it would seem reasonable to discard seedlings smaller than about 4 grams fresh weight.

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