Seedbed Density Influences Height, Diameter, and Dry Weight of 3-0 Douglas-Fir

Boyd C. Wilson and Robert K. Campbell[1]

Successful reforestation on many sites in the Douglas-fir region requires the planting of large stock, which is usually produced by nursery transplanting. Transplanted seedlings, however, are expensive and it is possible that lower cost 3-0 seedlings could replace them on some sites. This would require growing suitable 3-0 seedlings as a standard nursery practice; yet knowledge for growing 3-0 Douglas-fir seedlings is limited. Past observations suggest that their development is greatly influenced by seedbed density.

The main objective of this article is to describe the physical characteristics of 3-0 Douglas-fir grown at different spacings, and to show the relationship between those characteristics by using a series of curves which relate seedbed density, seedling diameter and height, seedling dry weight, and top/root ratios. The second objective is to compare diameter, height, and dry weight characteristics of 3-0 seedlings with 2-1 and 1-2 transplants from the same nursery. Finally, relative costs of producing transplants versus 3-0's is discussed.
No information obtained by field planting is included here.

Methods

Fifty dormant 3-0 seedlings were randomly selected and carefully lifted from each of four spacings (1 x 1, 3 x 3, 5 x 5, and 7 x 7 inches) that had been planted in four randomized blocks as part of a larger experiment carried out at the L.T. Webster Nursery at Olympia, Wash. These spacings represent densities of 144, 16, 5.8, and 2.9 seedlings per square foot, respectively. Heights and root collar diameters (outside the bark) were measured; then the roots were severed from the tops and both parts dried at 90°C until no further weight loss occurred. The average genetic quality of the trees was the same at each spacing.

[1] Respectively, forest geneticist, Washington State Department of Natural Resources, Olympia, Wash. and principal plant geneticist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oreg.

Results

Effect of Seedbed Density on Height, Diameter, and Dry Weight

At high seedling densities, root collar diameter increases gradually with an increase in growing space (fig. 1). However, at seedling densities below 25 per square foot, a much more rapid diameter increase occurs with each decrease in density. This

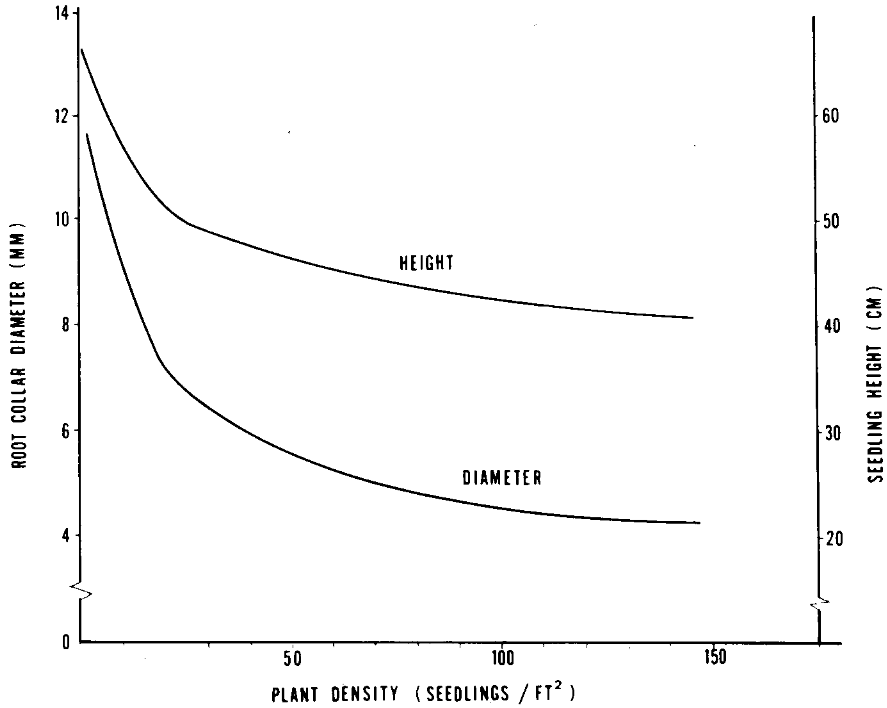


Figure 1.— Relationship of seedbed density to seedling height and diameter of 3-0 Douglas fir.

trend continues to the widest spacing in the experiment (2.9 seedlings per square foot), which indicates that even at this wide spacing (7" x 7"), there is still competition between seedlings.

Curves for diameter and height are similar, but diameter is more severely affected by plant density than is height. Diameter range in the experiment is 88 percent of the mean diameter while height range is only 44 percent of the average height, a 2-to-1 ratio. Dry weight of tops and roots follows the same trend with spacing as height and diameter, i.e., decreasing as density increases (table 1).

TABLE 1.–Average transplant[1] and predicted[2] 3-0 characteristics of 3-year-old douglas-fir grown at the Webster Nursery

Age	Final spacing Seedlings	Height	Diameter	O.D. weight			T/R ratio
				Tops	Roots	Total	
	Sq. ft.	*Cm*	*Mm*		*Gms.*		
1-2	8	73.0	10.42	31.08	8.60	39.68	3.63
2-1	8	33.5	6.99	8.55	4.69	13.24	1.84
3-0...............	4	62.0	10.7	39.1	14.3	53.4	2.74
	8	57.0	9.7	32.2	11.9	44.1	2.70
	16	53.0	7.8	21.0	7.6	28.6	2.78
	24	50.0	6.8	16.1	5.5	21.6	2.91
	32	48.0	6.4	14.3	4.9	19.2	2.94
	40	47.0	6.0	12.6	4.2	16.8	3.01

[1]Anderson, H.W. 1965. State of Washington, Department of Natural Resources, Unpublished Data.

[2]Heights and diameters predicted from plant density in figure 1; oven dry weights predicted from figure 3.

Relation of Height and Diameter to Seedling Dry Weights

Measurements of height (h) and diameters (d) of seedlings and the products of height times diameter-squared ($h \times d^2$) were related to seedling dry weights by regression at each of the spacings and all spacings combined. Height alone was not a good predictor of dry weight (fig. 2). In the equations used to predict dry weights within the separate spacing classes, h x d2 was sometimes a better predictor than diameter

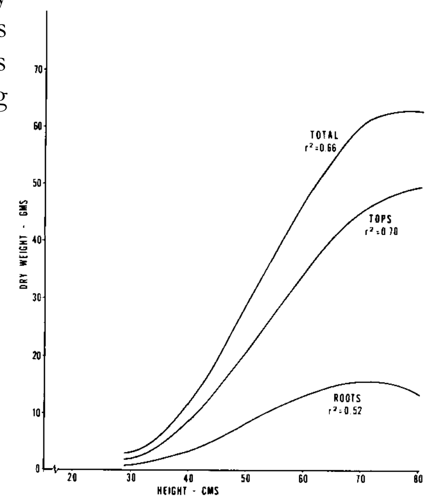


Figure 2. —Prediction lines for top, root, and total dry weight of 3-0 Douglas-fir based on total height.

alone, but a much more complicated regression equation was required to obtain a slight increase in precision (less than 5 percent). For most purposes, the extra costs of height measurement cannot be justified by the small increase in precision. For all spacings, h x d2 was responsible for 80, 94, and 91 percent of the variation in roots, tops, and total dry weight. Of the equations used to predict seedling weights for all spacings, the one based on diameter alone was best for explaining variation in dry weight (fig. 3).

The equations for relating diameter to root, top, and total dry weight are:

Tops= $Y=-56.68 + 23.15x+0.53x^2 +0.11x^3$

Roots = $Y = 56.80-27.07x +5.13x^2 -0.17x^3$

Total = $Y = 0.14 -3.39x +5.66x^2 - 0.06x^3$

WHERE

Y =predicted dry weight in decigrams X = root collar diameter in millimeters

Relation of Height and Diameter to Top/Root Ratio

By referring to figures 2 or 3, one can easily calculate a top/root ratio for any specified height or diameter of a 3-0 Douglas-fir seedling. For example, a tree with a diameter of 10 mm yields a root dry weight of 13 grams and a top weight of 34 grams (fig. 3). Dividing 34 by 13 equals a top/root ratio of 2.6. The curves for top/root ratios in figure 4 were developed by this method.

In both curves in figure 4, seedlings of intermediate size have minimum ratios. That is, within the height or diameter range of usual planting stock, unless the nurseryman uses additional cultural techniques, ratios less than about 2.6 or 2.7 would not be realized.

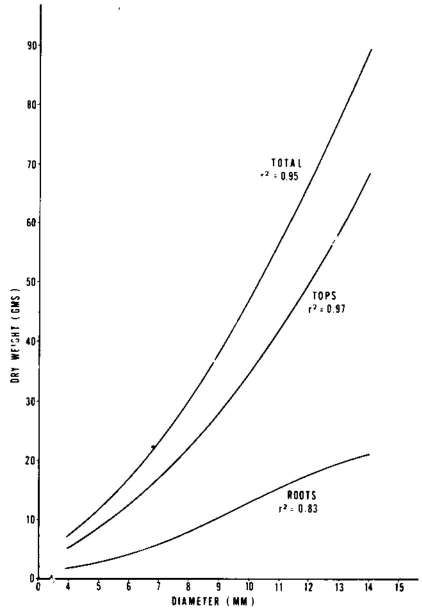


Figure 3. —Prediction lines for top, root, and total dry weight of 3-0 Douglas-fir based on root collar diameter.

We wish to emphasize that the ratios based on diameter are much more accurately estimated than those based on height. The latter should be used only in cases where diameter measurement would be either very expensive or impossible.

Transplants Compared to 3-0 Seedlings

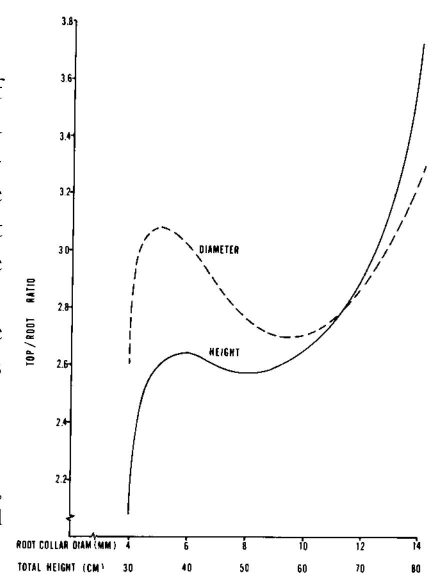
Some preliminary knowledge of the worth of 3-0 stock was acquired through comparison with 1-2 and 2-1 transplanted seedlings grown at the Webster Nursery. The transplant data came from four and three seedling lots, respectively, of 25 plants each.[2] These seedlings were grown at about 50 per square foot as 1-0's or 2-0's and at about eight per square foot as transplants. Two limitations to the data should be kept in mind when evaluating these comparisons: 1) The 1-2 and 2-1 transplants were grown several years prior to the spacing experiment which may introduce different year effects, and 2) although the 2-1 and 1-2 transplants come from identical seed lots, the 3-0 seedlings are from a different source.

[2]Anderson, H.W. 1965. State of Washington, Department of Natural Resources. Unpublished data.

Table 1 shows that traits of 3-0's are mainly intermediate to the two transplant types. When grown to comparable stem diameters, 3-0's are shorter than 1-2's and taller than 2-1's; their top/root ratios are smaller than 1-2's and larger than 2-1's. They appear to be heavier than either type.

Apparently within the seedling densities investigated, bed density cannot be manipulated to

Figure 4. — Curves predicting the top/root ratio of 3-0 Douglas-fir from root collar diameter and total height.



produce 3-0 seedlings with the same characteristics as transplant stock. However, we are suggesting that an intermediate type with an approximate average height of 55 cm., a diameter of 9 mm., and a top/root ratio of 2.7 can be produced if there is a need, and if production costs are acceptable. To grow this type in the Webster Nursery, we recommend sowing for eight to 10 seedlings per square foot (table 1). The development of appropriate cultural techniques, such as horizontal and vertical root pruning, would probably lead to improvements in the desired quality.

Cost Comparisons of 3-0 Seedlings Versus Transplants

At the Webster Nursery, in 1969-70, costs for 1-2 and 2-1 Douglas-fir transplants were $60 and $47 per thousand, respectively. Costs of 3-0 evergreen seedlings (of species other than Douglas-fir) were $26 per thousand. Consequently, the smallest apparent saving by using 3-0 stock is $21 per thousand.

This apparent saving is probably overestimated, especially if nursery bed space is at a premium. One thousand seedlings (3-0) produced at eight per square foot require 125 square feet of bed space in each of 3 years. In contrast, 2-1 transplants require 20 square feet in each of the first 2 years when grown at the normal 50 trees per square foot. If transplanted at a density of eight seedlings per square foot, they require an additional 125 square feet per thousand trees for another year. The total is 165 square feet for 3 years. Using the same arithmetic, 1-2 seedlings require 270 square feet. The average bed space per thousand trees per year is, then, 125, 90, and 55 square feet for 3-0, 1-2, and 2-1 seedlings, respectively. Obviously, where bed space is limited, transplants must be grown if the maximum number of 3-year-old trees is to be produced.

Conclusions

The conclusions reached can be summarized as follows:

1. Nursery spacing of Douglas-fir 3-0 seedlings affects both height and diameter even at densities as low as 2.9 seedlings per square foot. Diameter is affected more by spacing than is height.
2. Height and diameter can both be used to predict dry weight of seedling tops and roots. Diameter is a much better predictor of dry weight than is height.
3. Within the probable diameter and height range of normal planting stock, top/root ratios will likely not fall below 2.6.
4. Regardless of spacing, the Douglas-fir 3-0 seedlings did not have the same characteristics as 2-1 or 1-2 transplants.
5. Douglas-fir 3-0 seedlings use more cumulative bed space than transplants of the same age but are cheaper to produce.
6. Growing Douglas-fir 3-0 seedlings at eight to 10 seedlings per square foot is suggested to produce optimum planting stock.

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