Germination and Growth of Douglas-Fir and Incense-Cedar Seedlings on Two Southwestern Oregon Soils

Don Minore

Plant Ecologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oreg.

Douglas-fir and incense-cedar seeds were germinated and grown for 18 months with and without grass competition on soils derived from pillow basalt and marine sandstone. Grass reduced Douglas-fir germination on the basalt soil. Douglas-fir seedlings were heavier than incense-cedar seedlings on basalt soil where grass was absent, but incense-cedars were heavier than Douglas-firs on all other soil-grass combinations.

Clearcut stands of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) growing on soils derived from pillow basalt east of Sutherlin, Oregon, are often replaced by dense stands of grass and poison oak (*Rhus diversiloba* T. & G.). Survival of planted Douglas-fir seedlings is poor on many soils derived from basalt. There is less vegetative competition and better seedling survival in nearby clearcuts located on soils derived from marine sandstone. The clearcuts on basalt parent material and on sandstone are of similar age, with similar elevations, aspects, and slopes. They are less than 1-0 kilometers apart and have similar climates. Differences in vegetative competition and seedling survival appear to be associated with soil differences.

Parent material is only one factor in soil development, and soil is only one of the factors affecting plant growth. One can, however, compare the effects that different soils have on plant growth when other edaphic and environmental factors are equal (2). This study describes the growth of two native conifer species and a native grass on sandstone and basalt soils in a growth chamber. The two objectives were: (1) to compare the effects that soils developed from basalt and sandstone have on conifer germination and growth, and (2) to compare the responses of Douglas-fir and incense-cedar (*Libocedrus decurrens* Torr.) seedlings to grass competition on both soil types.

Materials and Methods

Three separate areas were sampled to obtain the basalt and sandstone soils used in this study. Sub-samples of equal size were collected 20 to 30 centimeters below the surface in the seedling root zone of three randomly located pits in each area. The nine sub-samples of each parent material were combined and mixed thoroughly. The blended soils were used to fill 14 x 14 x 14-centimeter pots to a depth of 12 centimeters.

Twelve pots of each soil type were sown with 7 Douglas-fir seeds, and 12 were sown with 7 incense-cedar seeds. The seeds, from sources near Sutherlin, were moistened and stratified at 1 ° C for 6 weeks before sowing. In six pots of each soil-tree combination, 28 blue wild rye (*Elymus glaucus* Buckl.) seeds collected near Sutherlin were also sown. Thus, four combinations were replicated six times on each soil: (1) Douglas-fir alone, (2) Douglas-fir + grass, (3) incense-cedar alone, and (4) incense-cedar + grass. The 48 pots were randomly arranged in a growth chamber set at 16-hour, 21° C days and 8 hour, 16° C nights. Average growth-chamber illumination (550 nm) at the soil surface was 30,000 lux. The pots were given equal amounts of water, but no nutrients were added.

Seed germination was monitored every other day for the first month. Seedlings were then thinned to the largest conifer and the 12 largest grass plants per pot. When the seedlings were 7 months old, growth chamber photoperiod and temperatures were reduced to 6-hour, 4° C and 18-hour, 2° C nights to induce dormancy. After 4 months, photoperiod and temperatures were increased to 14-hour, 21° C days and 10-hour, 16° C nights. These conditions were maintained until the plants were harvested 7 months later, 18 months after sowing.

Harvested conifer plants were washed free of soil, oven-dried at 65° C for 72 hours, and weighed to obtain oven-dry shoot and root weights. The weights were analyzed using a completely randomized design with a factorial arrangement of treatments. Germination percentages were analyzed in the same way after arc sin transformation.

Results and Discussion

Douglas-fir and incense-cedar seedlings are morphologically and physiologically different (1, 3), so differences in seed germination and seedling growth are to be expected. Species differences were not consistent under various soil and competition regimes used in this study, however, and these inconsistencies are of interest.

Douglas-fir germination was greater than incense-cedar germination on both soils. Grass did not reduce the germination of incense-cedar on either soil, but it did reduce Douglas-fir germination of basalt soil (table 1).

Field comparisons of juvenile conifer growth in southwestern Oregon (4) indicated that incense-cedar seedlings grew larger than Douglas-fir seedlings during the first 2 years in soils developed from pumice, rhyolitic tuff, and breccia parent materials. Similarly, early incense-cedar grew larger than Douglas-fir when grown without grass in soil developed from marine sandstone but not in soil developed from pillow basalt.

Douglas-fir seedlings grown in basalt soil were heavier than those in sandstone soil-with or without grass. In contrast, average

Table 1—*Average germination and weight of conifers grown in various soil-grass combinations*[1]

Conifer and treatment	Germination	Shoot weight	Root weight	Total weight	Shoot/root ratio
	%	g	g	g	
Basalt soil					
Douglas-fir alone	90.7	5.49	6.39	11.88	0.86
Douglas-fir + grass	66.7	1.32	1.31	2.63	0.88
Incense-cedar alone	19.0	3.25	6.97	10.22	0.47
Incense-cedar + grass	19.0	2.38	3.71	6.09	0.66
Sandstone soil					
Douglas-fir alone	83.3	2.90	3.46	6.36	0.83
Douglas-fir + grass	90.5	0.80	1.10	1.90	0.79
Incense-cedar alone	18.8	3.61	6.66	10.27	0.54
Incense-cedar + grass	21.5	1.25	1.84	3.09	0.68

[1]Means are based on six replicates. Differences were evaluated by analysis of variance.

incense-cedar weights did not differ for the two soils when the seedlings were grown without grass. With grass, the incense-cedar in basalt soil were about twice as heavy as those in sandstone soil. Grass competition reduced the average dry weights of both species by 70 percent in sandstone soil. In basalt soil, grass reduced the average seedling weight of Douglas-fir by 78 percent, but it reduced the average weight of incense-cedar by only 40 percent.

Incense-cedar roots were heavier than Douglas-fir roots in all soil-grass combinations (fig. 1). Roots of both species were heavier on basalt soil than on sandstone soil and heavier without grass than with grass. Soil x grass x species interactions were significant ($p = 0.01$) however. Grass competition reduced Douglas-fir root weights more than incense-cedar root weights in basalt soil but not in sandstone soil.

Grass had a similar effect on the shoots of both conifers in sandstone soil, but restricted the shoot growth of Douglas-fir more than that of incense-cedar in the basalt soil. Without grass, Douglas-fir shoots were heaviest in basalt soil and incense-cedar shoots were heaviest in sandstone soil.

Seedling shoot/root ratios were similar on both soils, but larger overall for Douglas-fir than for incense-cedar. Grass competition increased the incense-cedar shoot/root ratios on both soils, but did not affect Douglas-fir ratios.

The growth chamber conditions used in this experiment were not the same as field conditions. In fact, the germination and seedling weight information obtained in limited amounts of homogeneous potted soil under artificial light, temperature, and moisture conditions may not be applicable in the field. Neverthe-

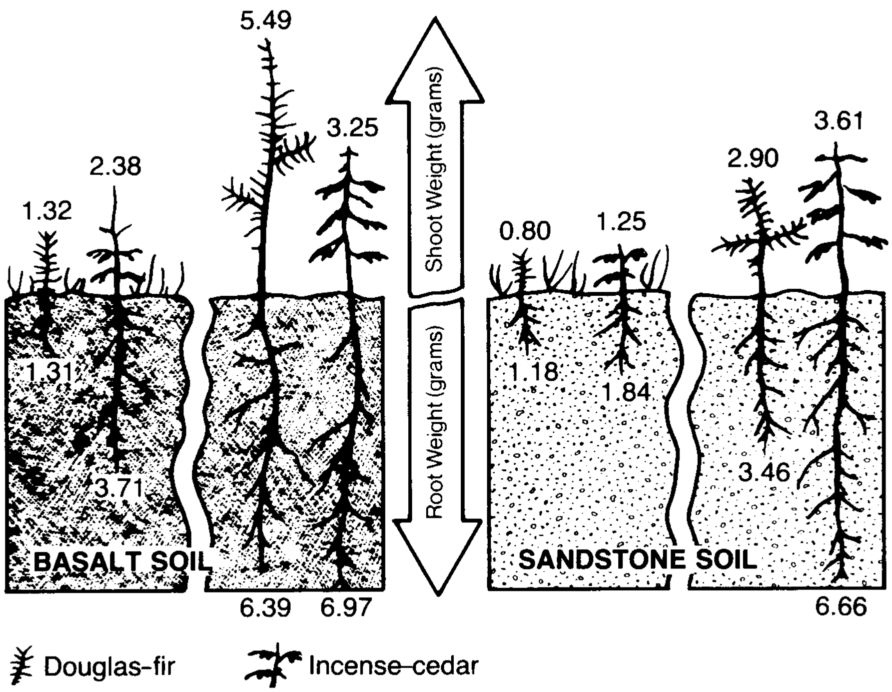

Figure 1—*Average shoot and root weights of Douglas-fir and incense-cedar seedlings grown in soils developed from basalt and sandstone parent materials, with and without grass.*

less, artificial conditions made it possible to compare soils and conifer species response without having to account for unmeasured variation in other factors. Explaining the differences in species response was difficult, however, because the factors causing the differences were not apparent.

Nutrient and moisture differences probably caused the observed differences in conifer growth. Basalt soil had a higher cation exchange capacity and more available nitrogen, calcium, and magnesium than sandstone soil (table 2). Because Douglas-fir seedlings may have been able to utilize the additional nutrients in basalt soil more efficiently, they grew larger than incense-cedar seedlings when supplied with abundant water in grass-free pots.

In pots where severe grass competition caused soil to dry out, moisture may have been the limiting factor for conifer growth. Although incense-cedar is more drought tolerant than Douglas-fir, the two species reacted similarly to grass competition in sandstone soil. When grown with grass in basalt soil, incense-cedar grew better than Douglas-fir, but not necessarily because of drought tolerance. The Douglas-fir seedlings may have shown poor growth because they could not use nutrients in dry basalt soil as efficiently as they could in wet soil.

Table 2—*Properties of soils developed from pillow basalt and marine sandstone parent materials*

Soil property	Pillow basalt	Marine sandstone
Sand (%)	39	55
Silt (%)	37	28
Clay (%)	24	17
pH[1]	6.4	5.6
C.E.C. (Meq/100 g at pH 7.0)	39.48	8.64
Total N (%)[2]	0.140	0.062
NO_3-N (mg/kg)[3]	2.00	0.28
NH_4-N (mg/kg)[3]	6.60	4.82
P (%)[4]	0.000	0.001
K (%)[5]	0.247	0.475
Ca (%)[5]	1.349	0.463
Mg (%)[5]	1.839	0.484
S (%)[6]	0.044	0.063

[1]Soil-water paste.
[2]Kjeldahl.
[3]Water extractable.
[4]Acid extractable (Bray method).
[5]Extractable (NH_4OAc at pH 7.0).
[6]Sulfate S.

Literature Cited

1. Franklin, J. F. A guide to seedling identification for 25 conifers of the Pacific Northwest. PNW-Misc. Pub. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1961. 65 p.
2. Kruckeberg, A. R. Soil diversity and the distribution of plants, with examples from western North America. Madrono 20: 129-154; 1969.
3. Minore, D. Comparative autecological characteristics of northwestern tree species-a literature review. Gen. Tech. Rep. PNW-87. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979. 72 p.
4. Stein, W. I. Comparative juvenile growth of five western conifers. New Haven, CT: Yale University; 1963. 194 p. Ph.D. dissertation.