The Aquarium Tester--A Fast, Inexpensive Device for Evaluating Seedling Quality

Larry Palmer and Ivend Holen

Forestry technician and silviculturist, Butte Falls Resource Area, U.S. Department of the Interior, Bureau of Land Management, Medford, OR

*Materials and methods for a hydroponic test of root growth potential are described, and the technique is used to evaluate Douglas-fir (*Pseudotsuga menziesii *(Mirb.) Franco) seedlings that were outplanted in the southern Cascade mountains.* Tree Planters' Notes 37(3):13-16; 1986.

The Medford BLM District has been evaluating a method of hydroponically determining the quality of its lots of lifted Douglas-fir seedlings prior to planting. With this method, samples of at least 15 seedlings from each lot to be tested are removed from the newly delivered bags and boxes and the roots placed in simple 10-gallon aquariums (fig. 1). After 14 days, new root growth is readily apparent and measurable, and the quality of the stock can be evaluated by counting the number of new root tips 1 centimeter and longer.

The significance of this aquarium root growth was evaluated last summer in the field in a formal research study in which the seedling survival of nursery lots was compared with contrasting levels of seedling root growth. The first year results indicate that a positive and notable correspondence exists between the number of new roots produced in 14 days in the aquarium test and field survival of seedlings from the same lots. An inexpensive practical method to help users evaluate the quality of their seedlings prior to outplanting is outlined in the article that follows, along with the results of the research study we implemented.

Figure 1—*Aquariums with aerators and seedlings installed.*

Constructing the Aquarium Tester

Materials for the construction of one aquarium tester can be purchased for under $65.00 (table 1). Access to a band saw and drill press reduces labor and construction time. If these tools are not

Table 1—*Materials for the construction of the aquarium tester*

Materials	Quantity	Approx. cost ($)
10-gallon glass aquarium	1	15.00
¼-inch-thick Plexiglas top (12 by 20 inches)	1	9.00
Air pump	1	6.00
Air pump tubing per foot	5	.50
Aerator stone	1	1.00
#11½ black rubber stopper	15	15.00
Aerosol paint can	2	3.00
Glass tube aquarium heater	1	5.00
Total cost		62.50

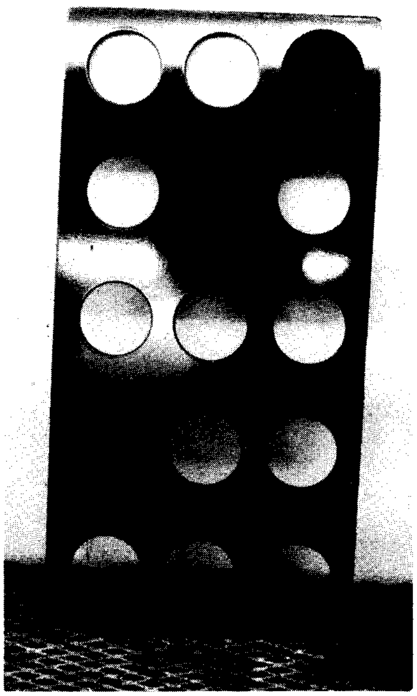

Figure 2—*Painted Plexiglas aquarium cover with $2\frac{1}{4}$-inch holes and rubber stoppers.*

available, a hand-held half-inch drill, a vise or clamps, a circular or band saw, a $2^{1}/_{4}$ -inch hole saw, and a hacksaw will suffice.

Obtain a piece of Plexiglas approximately 12 by 20 inches and trim with the band saw or circular saw to fit the inside lip at the top of the tank (fig. 2). Do not use plywood; it warps, allowing light to enter the tank easily. Using the hole saw, cut up to fifteen $2^{1}/_{4}$ inch holes in which to insert rubber stoppers. A half-round file may be needed for smoothing any rough edges. At some point on the edge of the lid, cut or drill notches for the air tube and aquarium heater to enter the tank. The top should be painted black to keep out light. Lightly sand the Plexiglas top to help paint adhere.

Clean the outside glass surfaces of aquarium thoroughly before painting so that paint will adhere. Black electrical tape may be used to cover seams and missed spots. Take care to ensure that paint does not come in contact with the underside of the lid or inside of the aquarium, for toxic substances in the paint may harm the seedlings.

Turn the tank upside down and paint it. Cut a line in the stoppers from the outside edge to the center hole so that the seedlings can be inserted.

Once the paint is dry, fill the tank with fresh water and connect the air pump. A small air pump has the capacity to aerate one tank. Use fresh water in a thoroughly sterilized apparatus (liquid bleach works well) each time a test is run. Attach the aquarium heater and set it to maintain a minimum water temperature of 68 to 70 °F at least 1 day prior to placing seedlings in the tank.

Be careful not to damage the bark or cambium layers when inserting the seedlings in the stoppers (fig. 3). Tight center holes should be enlarged, and seedlings smaller

Figure 3—*Plexiglas cover with rubber stoppers and seedlings installed.*

than the holes can be held in place with cotton wool.

After 14 days in the aquarium, remove the seedlings and clip all new white roots over 1 centimeter long. Roots can be quickly removed with clipper or fingernail. Count and measure roots from all seedlings and divide by the number of test seedlings to establish the root growth class for the seedling lot (table 2). Although correlation between these classes and subsequent seedling performance is tentative, planting recommendations are listed in table 2.

Table 2—*Root growth classes and subsequent performance*

Class	Description*	Planting quality
0	No new growth	Dead or very poor—do not plant
1	Some new roots, none over 1 cm long	Dead or very poor—do not plant
2	1 to 3 new roots over 1 cm long	Poor to fair—plant on low-stress sites only
3	4 to 10 new roots over 1 cm long	Good quality—plant on typical new sites
4	11 to 30 new roots over 1 cm long	Excellent—plant on droughty sites
5	30+ new roots over 1 cm long	Superior—plant on toughest sites

*From Burdett (*1*).

Figure 4—*Douglas-fir seedling roots after 14 days in tank. Class 4 = 11 to 30 new roots measuring over 1 centimeter.*

Root Growth Potential Test

Thirty Douglas-fir seedlings produced from certified seed of the same seed source but grown at two different west Cascade nurseries (15 seedlings from each) were tagged and randomly placed in two aquarium testers on April 5, 1985. Root growth was visually evaluated 2 weeks later (fig. 4), but seedlings were left in the tanks for an additional week (for a total of 3 weeks) before the final evaluation and clipping on April 26. Little or no root growth was noted after the previous inspection.

The evaluation indicated that the seedlings produced by nursery A had a range of 1 to 4 new root tips that were 1 centimeter and longer per seedling, with an average of 2.33 roots per seedlings; this corresponds to root growth class 2--poor to fair. For nursery B, the number of new roots ranged from 1 to 16 per seedling, with an average of 7.4. This corresponds to root growth class 3-good quality.

Outplanting Trial

Four hundred 2-0 bareroot seedlings from nursery A and nursery B (200 each) were planted by skilled planters on April 4, 1985, at a test site in southern Cascade mountains north of Butte Falls, Oregon. The planting layout followed a randomized complete block design with four replications on a tractor-scarified and ripped south-facing clear-cut (slope less than 30 percent) at 3,240 feet in elevation. The site had been operationally planted the previous year with survival exceeding 90 percent. No gopher damage nor deer browsing was observed on the previously planted seedlings, and very little grass was present, but heavy infestations of bull thistle developed in the summer of 1985. This competition may have affected variation in survival among replications, making detection of the effects of seedling quality on survival more difficult. Survival was measured twice during 1985; in August and in late October. Percent survival of seedlings from nursery A was 81 percent in August and 50 percent in late October as compared to nursery B with 90 percent and 66 percent at those times.

Discussion

In this study, differences in seedling root growth for the two nursery lots were congruent with first-season seedling survival in the field. Seedlings with the lower root growth potential, as measured by the aquarium tester, performed more poorly after outplanting. Observations of operationally planted seedlings from the two nursery lots involved corroborates the root growth and field survival test; the seedling lots with the lower root growth survived less well. In addition, the general appearance and condition of the surviving seedlings at the end of the first growing season was notably better for the seedling lots that tested better in the aquariums.

Conclusion

Determining the root growth potential of Douglas-fir seedlings hydroponically may have some potential as a predictor of seedling quality prior to planting. Articles and publications by Ritchief (5), McCreary and Duryea (4), Stone and Jenkinson (8), and Burdett (1) indicate that root growth potential is positively correlated with first-year survival and growth. Using this method, measurable results may be obtained in 14 days, compared to the 25- to 45-day period required by the growth chamber method of potting seedlings and evaluating subsequent bud break and flushing (2).

Other advantages of this method are that no growth chamber is necessary, root growth is visible, roots are easily accessible and easily measured, and there is no loss of new root tips in the growing medium. Further testing is necessary to more precisely define the relationship between water temperature of the aquarium and the minimum time before measurement, the best minimum length of new root tips to count, and the closeness of the relationship between the classes and field performance of the seedlings. With development of the aquarium tester, however, foresters and other nursery users, with minimal investment, can begin to evaluate their seedling stock while it is still in the cooler, and also help answer some of the questions posed above.

References

1. Burdett, A. N. New methods for measuring root growth capacity: their value in assessing lodgepole pine stock quality. Canadian Journal of Forest Research 9:63-67; 1979.
2. Hermann, R.K.; Lavender, D.P. Testing the vigor of coniferous planting stock. For. Res. Lab. Res. Note 63. Corvallis: Oregon State University School of Forestry; 1979.
3. Jenkinson, T.L. Seasonal patterns of root growth capacity in western yellow pines. In: Proceedings, Society of American Foresters national convention, 1975:445-453.
4. McCreary, D.; Duryea, M. Evaluating seedling quality: a preliminary study to examine the OSU vigor test, the root growth capacity approach and other assessment procedures-report #2, first year growth and survival. Unpublished report of Oregon State University, Department of Forestry, Nursery Technology Cooperative. Corvallis. 1983.
5. Ritchie, G.A. Assessing seedling quality. In: Duryea, M.L.; Landis, T.D., eds. Forest nursery manual: production of bareroot seedlings. The Hague: Nijhoff/ Junk Publishers, for Forest Research Laboratory, Oregon State University; 1984: 244-246.
6. Ritchie, G.A. Root growth capacity: what are its limitations? unpublished paper presented at True Fir Management Symposium, "Regeneration and Management of True Fir Stands." Bedding, CA; 1979.
7. Stone, E.C.; Jenkinson, J.L. Physiological grading of ponderosa pine nursery stock. Journal of Forestry 69:1, 31-33; 1971.