The Operational Seedling Testing Program at Weyerhaeuser

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Tanaka, Y.; Brotherton, P.; Hostetter, S.; Dyce, S.; Chapman, D.; Belanger, J.; Johnson, B.; Duke, S. 1994. The Operational Seedling Testing Program at Weyerhaeuser. In Landis, T.D.; Dumroese, R.K., technical coordinators. Proceedings, Forest and Conservation Nursery Associations. 1994, July 11-14; Williamsburg, VA. Gen. Tech. Rep. RM-GTR-257. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 256-260. Available at: http://www.fcnanet.org/proceedings/1994/tanaka.pdf

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Abstract—The Weyerhaeuser Seedling Testing program was established in 1985 to evaluate root growth potential, greenhouse viability, cold hardiness and morphology of nursery seedlings. This system is designed to identify and minimize the use of poor quality stock and help develop good working relationships with customers. Laboratory test results are compiled as baseline data for interpretation of future test results.

INTRODUCTION

The Weyerhaeuser seedling testing program called the Seedling Testing System (STS) was developed and implemented at the Weyerhaeuser Western Forestry Research Center, Centralia, Washington in 1985. The main purpose of the system is to determine and monitor the quality and condition of planting stock. About 500-800 tests are conducted annually, providing testing services to nine company seedling production facilities in six states (five in the Pacific Northwest and four in the Southeast) and, to a limited extent, to outside customers on a fee basis.

The STS is capable of determining the following four seedling characteristics:

1. *Root Growth Potential (RGP)* – The ability of a seedling to produce new roots in a greenhouse or growth chamber that is conducive to optimum root growth. The RGP is considered to be a good indicator of the general vigor and health of seedlings (Ritchie 1985).

2. *Greenhouse Viability (GV)* – The condition of the bud, stem cambium and foliage of the same seedlings used in the RGP tests determines the viability. A seedling is considered non-viable (likely to perform poorly in the field) if one of the following conditions exists: (1) 50% or more of the buds are dead (may not apply to pine and some other species), (2) stem cambium tissue is dead around the circumference of the lower 1/2 of the main stem, or (3) 80% or more of the foliage is damaged (unless there are 5 or more new roots greater than or equal to 1 cm. in length). The GV thus also provides information on the general vigor and health of seedlings.

3. *Cold Hardiness (CH)* - The ability of a seedling to withstand various levels of subfreezing temperatures, cold

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hardiness test results are used in the frost control program in the nursery and in various other regeneration decisions (Timmis et al 1994).

4. *Morphology* **-** The external characteristics including height, root collar diameter, shoot and root dry weights and root to shoot ratio (Thompson 1985).

SEEDLING TESTING PROCEDURES

Root Growth Potential (RGP) Test:

Twenty seedlings (4 pots of 5 seedlings per pot) from each lot are potted into two gallon pots in a peat:perlite (3:2) mix and grown in a growth chamber for 7 or 14 days or in a greenhouse for 4 weeks. In the growth chamber (7-day and 14-day RGP tests), the root temperature is maintained as close to 20°C as possible with a relative humidity of 75%+. The daylength is maintained at 16 hours using high pressure sodium vapor lamps, which provide about 400 µE/m^2/sec. at foliage height. In the greenhouse (4-week RGP test), the root temperature is maintained as close to 20°C as possible with a relative humidity of 50%+. Seedlings are grown with natural sunlight extended to sixteen hours using cool white fluorescent lamps.

At the conclusion of the tests, new roots longer than or equal to 1 cm. (Figure 1) are counted and the values are then converted into a modified Burdett's (Burdett 1987) root growth index (RGI) using the following scale:

RGI	Number of new roots >1 cm.
0	No new roots
1	Some new roots, but none >1 cm
2	1 - 3
3	4 - 10
4	11 - 30
5	31 - 100
6	101 - 300
7	over 300

The purpose of the conversion to RGI is mainly to minimize the possible biases associated with the use of the mean number of new roots, which sometimes becomes misleading when a few trees produce an unusually large number of new roots.

Using the baseline data and research results, we have determined the threshold RGI value (Ritchie and Tanaka 1990) for three main stock types of Douglas-fir.

Stock Type	14-day RGP	4-week RGP
1+1	3.0	4.8
2+0	2.0	4.0
MPT*	3.0	4.0

*MINI-PLUG™ transplant, grown in the greenhouse for 5-6 months and transplanted into the nursery bed for one season (Hee et al 1988, Tanaka et al 1988).

This is the value below which the quality of stock is considered to be less than optimum and greenhouse viability is often less than 90% (Figure 2).

Greenhouse or Growth Chamber Viability (GV) Test:

GV is determined using the tops of the same sample seedlings used in the RGP tests and is expressed as a percentage of viable trees. A tree is considered to be dead if one of the following conditions exists:

1. Fifty percent or more of the buds are dead out of ten buds examined (if available). This may not apply to some pine and deciduous species.

2. Stem cambium tissue is dead around the full circumference anywhere on the lower half of the main stem.

3. Eighty percent or more of the foliage is damaged (however, if the number of new roots 1 cm. is five or more, the tree is considered viable).

Cold Hardiness Test:

Cold Hardiness is estimated using whole-plant freeze tests followed by visual damage assessment. It is expressed as the lethal temperature in °C that kills 10% and 50% of a given lot (LT_{10} and LT_{50}).

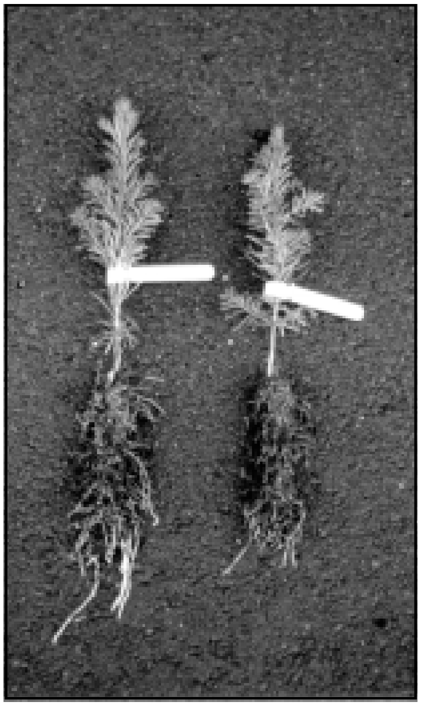

Figure 1. RGP test showing differences in the number of new roots produced by 2 noble fir plugs.

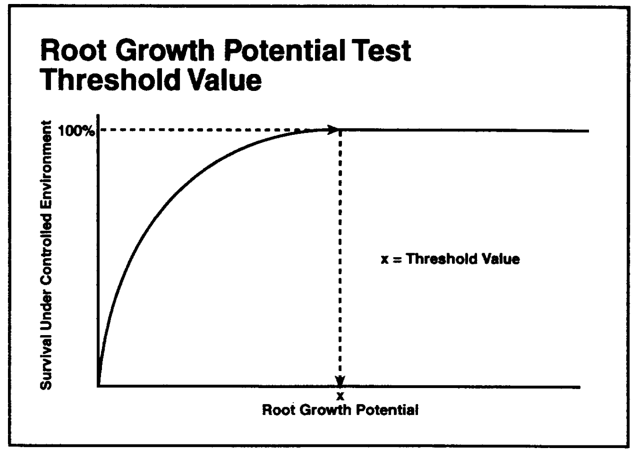

Figure 2. Threshold RGI values are estimated by determining the lowest RGI that still maintains 100% survival in a controlled environment.

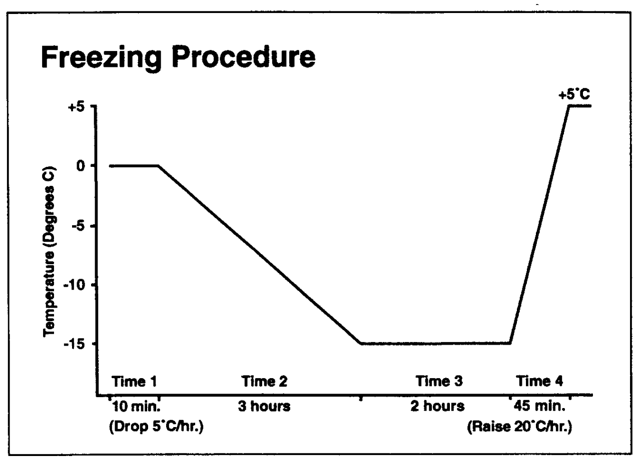

Figure 3. Ramp and hold procedure for exposure to sub-freezing temperatures in the cold hardiness test.

For most stock types, ninety sample trees are divided into 18 groups of 5 trees each. For larger stock types such as 1+1 and 2+1, the sample trees are divided into 30 groups of 3 trees each. Each group is potted into a one gallon pot in peat:perlite (3:2) mix. Pots are placed into insulated boxes to protect the roots from freezing temperatures. Fifteen trees (3-5 groups) are then exposed to four or five sub-freezing temperatures in a controlled freezer (Thermatron, Holland, Michigan). Depending on the lift date, temperatures are selected to bracket the LT_{10} and LT_{50}. For each exposure, the temperature is lowered at a rate of 5°C per hour, held at the test temperature for 2 hours and then raised back to room temperature at a rate of 20°C per hour (Figure 3).

Following freezing exposure, trees are moved into a greenhouse. The air temperature is maintained as close to 20°C as possible with a relative humidity ranging between 30% and 70%. The daylength is extended to 16 hours using cool white fluorescent lamps.

Trees are evaluated for cold damage after a seven day incubation period in the greenhouse. A tree is considered to be dead if one of the following conditions exists: (1) 50% or more of the 10 buds assessed are dead, (2) cambium is dead around the full circumference anywhere on the lower half of the main stem, (3) cambium and buds are questionable and needle damage is 80% or more. (Needle damage is used in combination with the bud and cambium condition, not by itself, in determining mortality of questionable trees.)

Morphology Test:

Measurements are done on 20 sample seedlings. Tree height is measured in cm. from the root collar (positioned 1 cm. below the cotyledon scar in most species) to the base of the terminal bud. Stem diameter is measured in mm. at the root collar. Shoot and root dry weights are determined in grams after drying them at 70°C for at least 48 hours. The 20 samples are weighed in four groups of 5 seedlings, but the results are expressed as the mean weight of the individual tree. Root dry weight is divided by the shoot dry weight to determine the root to shoot ratio.

Reporting

Through the use of a SAS-based (SAS Institute Inc., Cary, NC) computer program, the seedling test results are analyzed and summarized, giving the client information on individual test seedlings as well as the frequencies, means and standard deviations for each parameter tested. Results are often faxed to clients within the same day of assessment to assist in making important management decisions. The seedling testing results are archived, yielding baseline data for each species and stock type combination by nursery and are used for interpretation of test data. Values in the lower quartile of the baseline data or those below threshold value are considered below normal and recommendations may be made to the client depending upon the circumstances. If low values are due to environmental damage (such as a cold event in the nursery), we recommend the seedlings be left in the nursery bed or in storage for recovery. In other situations, a recommendation may be made to increase the number of seedlings planted or to plant the affected stock on a milder site.

CURRENT RESEARCH

In addition to the above operational seedling testing, research is being conducted in the following areas:

Seedling Testing Field Trial

Research is being conducted to correlate laboratory seedling testing results after a nursery cold event with actual field performance. The results will allow us to estimate field performance of stock having various levels of RGP and GV under a range of field environments.

Seedling Stress Test

Tests are in progress to develop a reliable method to quickly evaluate the condition of stock with a suspected quality problem. A shorter test with a three to seven day turn around time would greatly help customers make important regeneration decisions. The feasibility of testing viability under stressful environments is being evaluated for this purpose.

Variable Chlorophyll Fluorescence

Tests to determine the variable chlorophyll fluorescence profiles of seedlings would provide a rapid and accurate method of assessing seedling damage in a non-destructive manner (Hawkins and Binder 1990). Both non-modulated and fully modulated fluorometers are being tested to evaluate the usefulness of this technique.

CONCLUSIONS

The Seedling Testing System (STS) provides accurate, repeatable assessment of the quality and condition of planting stock. STS minimizes the utilization of poorer quality stock that might result in regeneration failure, potential crop losses due to pathological problems in the greenhouse and nursery, and provides assistance to the company nurseries in developing good working relationships with outside seedling customers. By tracking the test results of various seedlots, we are able to monitor the progress of our continuing goal to produce high quality seedlings with superior survival and growth potential.

ACKNOWLEDGMENTS

We would like to thank the following people for their help and support throughout various phases of the project: Jim Bryan, Steve Altsuler, Jerry Barnes, Tom Daniels, Debbie Johnson, Rod Miller, Mike Pfaff, Tom Stevens, Gale Thompson and Mark Triebwasser for technical advice and assistance, providing testing materials and facilitating outside customer's and bench marking work; Mitch Allen, Byron Carrier, Jim Clarke, Alex Dobkowski, Dick Ford, Greg Jones, Tim Kosderka, Martin Lugas and Chris Sokol for field evaluation and technical advice; Jack Englund, Jim Keeley, Mike McKinnis, Ed McLaughlin, John Wakefield and Doug Waldren for maintenance, repairs and upgrading of testing facilities and equipment; John Browning, Bill Carlson, Will Littke, Gary Ritchie, Roger Timmis and Patty Ward for various technical support and advice; Carol Morehead, Carol O'Brien and Betty Styger for carrying out RGP, morphology and cold hardiness tests and Tina Allen, Donna Loucks, Susan Sweetingham and Frances Tanaka for preparing reports and literature search. We are particularly grateful to Steve Cafferata, Steve Hee, Tom Terry and Cheryl Talbert whose support and advice have been most helpful in initiating and establishing the Weyerhaeuser seedling testing program.

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