A Stock Quality Assessment Procedure for Characterizing Nursery-grown Seedlings - FRDA Report 069

For successful reforestation, foresters must be able to match seedling performance potential with expected field conditions. Often, these conditions are not optimal. This study examines testing procedures that predict a seedling’s potential success under field conditions that severely limit growth and survival. Western hemlock (Tsuga heterophylla Raf. Sarg.) and western redcedar (Thuya plicata Donn) seedlings were grown in containers in a greenhouse under four different cultural regimes. The seedlings were examined with different stock quality assessment procedures to characterize their drought avoidance (needle and root surface area, needle resistance, root growth capacity), drought tolerance (osmotic potential), and cold temperature (frost hardiness and low temperature root growth capacity).

Only partial stock performance-potential test results were presented in the report.

The study was conducted at the Pacific Forestry Centre in Victoria. Seed from both species was sown in March 1987 in identical styroblocks and maintained under the same growing regime until July 1987. Mean seedling shoot height was 15.8 and 16.3 cm for the western hemlock and western redcedar respectively. One quarter of the seedlings of each species were tested with four dormancy development treatments:

1. Long-day wet (LDW); seedlings continued to receive the initial greenhouse regime until the end of August.

2. Long-day dry (LDD); seedlings had the extended photoperiod as in the initial greenhouse regime, but a moisture stress treatment was initiated.

3. Short-day dry (SDD); seedlings had a moisture stress treatment initiated and their photoperiod reduced to 8 hours at the beginning of August.

4. Short-day wet (SDW); seedlings continued to receive the initial watering and fertilization regime until the end of August but had the photoperiod reduced to 8 hours at the beginning of August.

All dormancy induction treatments were concluded at the end of August and the regular greenhouse regime re-established. Fertilizer was applied weekly until November and twice weekly thereafter. Temperatures (day/night) were best at 20/10°C until September 15, 17/8°C until October 10, 15/5°C until October 15, 13/4°C until November 11, 8/0°C until seedlings were put into cold storage (2°C) on January 11, 1988.

In the moisture stress treatment, styroblocks were allowed to dry down to approximately 2.85 kg below their saturated weight before rewattering to saturation, plus fertilizing and repeating the dry cycle. Throughout the 6-week period seedlings were subjected to six drying cycles and the xylem pressure potential monitored.

**GROWING SEASON HEIGHT GROWTH**

Seedling shoot height was nondestructively assessed throughout the study period. The findings showed that western hemlock seedlings in the short-day treatments ceased shoot elongation by the end of the dormancy induction treatment, August 28. Seedlings in the long-day treatments continued shoot extension until early October. Short-day treatments had a greater effect on the phenology of shoot growth than moisture stress treatments.

Western redcedar seedlings seasonal shoot height did not show any response to nursery cultural treatments. The investigators suggest that the cultural treatments may not have been sufficiently severe or may not have included the proper environmental cues to affect shoot height. However, it was noted that seedlings of both species were tested at 22°C in this study, while in normal conditions seedlings are planted when soil temperatures are just above 5°C. An RGC test which examines root responses at low root temperatures might provide a stress tolerance test that more effectively predicts the effect of nursery cultural treatments on early root growth in field-planted seedlings. In the low temperature test western hemlock seedlings from the SDW and SDD treatments produced RGC values that predicted good field survival. Western redcedar seedlings did not show any treatment differences. More work is required in this area.

**STOCK PERFORMANCE POTENTIAL TESTS**

During January and February 1988 seedlings from both species in all treatments were assessed for physiological and morphological characteristics with the following results:

**Needle and Root Surface Area**

Surface area measurements determined the needle transpiration area to root absorption area. Then selected seedlings were dissected and shoot and root sections processed through a LI-3100 area meter.

The results showed that short-day and moistures stress treatments reduced needle surface area in both species, consequently these two treatments improve the root/shoot ratio and thereby produce a higher quality seedling: the higher the root/shoot ratio, the better the field survival. The root surface area was similar within each species between all
treatments. The investigators suggest this finding is contrary to the widely held belief that nursery cultural practices that stop shoot growth will result in a partial transfer of that seedling growth potential into root growth as well as caliper and bud development.

Root growth capacity
Two tests were applied to each species/treatment combination. With the standard soil/pot test, seedlings were grown for 7 days in a greenhouse regime, at which time root development was assessed with Burdett's semiquantitative scale. In the hydroponic test, seedling root systems were placed in a darkened aerated aquarium under a specified growing regime for 14 days, then examined with a root classification system modified from Burdett's.

The results of the tests differed depending upon the testing procedure. As expected under the optimal root temperature conditions the 7-day soil/pot system produced fewer roots than the 14-day hydroponic system in comparable species/treatment combinations. The investigators suggest this difference between the two testing procedures was due to study length. They also suggest that these differences may not be biologically important because all RGC classifications were four or greater throughout all treatment/species combinations, and outplanting studies have shown that with RGC values of 1 to 3, field survival is usually greater than 80%. Thus all seedlings in this study have the potential for good field survival.

Frost hardness
The standard provincial procedure of the seedling browning test was used and frost hardness was assessed for all species/treatment combinations at -9, -12, -15 and -18°C. The findings showed that seedlings of both species in the LDW treatment had the least frost hardness. Also, western hemlock seedlings developed greater frost hardness in the short-day treatments, while western redcedar developed greater frost hardness in the moisture stress treatments. The investigators noted that the combination of short-day and moisture stress was not as effective in conferring frost hardness as just the short-day treatment in western hemlock and the moisture stress treatment in western redcedar. This lack of synergism between short-day and moisture stress to improve frost hardness suggests that the combined influence creates an environment too stressful for full frost hardness development.

Osmotic potential
Pressure-volume analysis was used to find the osmotic potential at saturation and turgor loss point. Six replicates for each species/treatment combination were used for pressure-volume curves. Osmotic potentials values were then calculated by computer. Osmotic adjustment in western hemlock seedlings was greatest in the SDW followed by the SDD treatment. The investigators suggest, from other research, that these short-day treatments in western hemlock could have promoted increased sugar and organic acid production resulting in increased osmotic adjustment. Western redcedar seedlings showed only a slight osmotic adjustment. Again citing other research, the investigators suggest that the drying cycles were not long enough to develop sufficient seedling water stress for greater osmotic adjustment to occur.

Needle resistance
Needle resistance was used to determine cuticular development for all combinations. Seedlings were placed in the controlled environment room (used in the root growth tests), well watered for 5 days, then allowed to slowly dry down. Seedlings were monitored throughout this period for needle resistance, measured in a foliage cuvette with a porometer. Also, at the experiment's end sample branches were removed and needle surface area determined with a Li-3100 area meter. Western hemlock under water stress conditions (ie. -1.5 MPa) resulted in the LDW and LDD treatments having the greatest level of needle resistance. This was contrary to the working hypothesis that needle resistance is a combination of stomatal, mesophyll, and cuticular resistances. The premise is that as long as the stomata are partially open they are the primary factor influencing needle water loss, and should the stomata be forced to close (e.g., via seedling water stress and/or darkness), the subsequent measurement of needle resistance would represent the cuticular resistance of the needle. Given this, the findings in this study are still compatible if the needle resistance measurements here are examined in conjunction with the osmotic potential data. This evidence shows that these needle resistance measurements were taken at a medium level of water stress for western hemlock, and in this condition the SDW and SDD treatments responded to the moderate stress by keeping their stomata open slightly during the dark phase. Western redcedar showed high needle resistance in the SDD and SDW treatments at the -1.5 MPa measurement time. Western redcedar seedlings at this measurement time had enough daytime seedling water stress to result in stomatal closure; thus, the cuticular resistance was highest. Short-day and moisture stress treatments seem to reduce needle water loss in western redcedar.

The testing system in this study was a first approximation of stock quality assessments procedures that examine how seedlings, treated with different nursery cultural regimes, will respond to potentially deleterious field conditions. Further refinements of the needle resistance and low temperature RGC tests are required. However, once these are incorporated, foresters will be able to determine seedling performance potential as it relates to both optimal and deleterious field site conditions.

Daylength and moisture stress treatments, as applied here, can influence the physiological and morphological characteristics of western hemlock. However, they only influenced some of these physiological and morphological characteristics of western redcedar seedlings. Western hemlock seedlings in the SDW and SDD treatments and western redcedar seedlings in the LDD and SDD treatments had the best overall stock performance potential characteristics.

Copies of the 12-page report, A Stock Quality Assessment Procedure for Characterizing Nursery-Grown Seedlings by S.C. Grossnickle, J.T. Arnott and J.E. Major, are available while supplies last from:

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