Root Growth Potential in Coastal Container Species: Trends from Operational Testing and Prediction of Outplanting Performance

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Abstract. One-week root growth potential tests appear adequate for operational go/no go decisions on coastal container and bareroot planting stock. Stress resistance mechanisms related to dormancy intensity and cold hardiness appear to play a more significant role than root growth potential for seedlings with a reasonable ability to produce roots.

INTRODUCTION

Assessments of a seedling's ability to produce roots have been evolving since the work of E.C. Stone in California in the late 1950s. Much of the initial work focused on understanding the progression of root phenology in seedlings, what the root growth stimulus was, and how it might be related to such things as bud dormancy, carbohydrates (current or stored) and outplanting vigor.

The major impediment to using root growth potential assessments as an operational forestry tool was the two-month duration of the test. By the time "poor" seedlots were identified, it was too late to act. A.N. Burdett[2] (1979) developed a rapid test (1 week) and assessment method which made possible operational assessment in white spruce and lodgepole pine. This method was found to be well correlated with outplant survival.

MacMillan Bloedel (MB) had been concerned about plantation performance in coastal conifers for many years prior to the development of Burdett's test in 1979. Most foresters believe many of their plantation failures could have resulted from poor stock quality.

The establishment of a private container nursery in 1979 and confirmation of a number of bareroot plantation failures in 1982 being directly related to low root growth potential, led to MB instituting operational root growth potential monitoring in 1984.

The operational testing was established as the first in a series of steps to:

- eliminate planting stock with a low probability of success prior to shipment
- improve nursery culture to such a point that the probability of producing low vigor planting stock was minimized.

ROOT GROWTH POTENTIAL (RGP) METHODOLOGY

The rapid RGP test[2] has been used as an operational monitoring system by MB in the following fashion:

1. Sampling: Samples (25 trees/seedlot) are taken on a regular basis from time of lift to time of plant.

2. Growing Medium: Seedlings are potted in 20-centimeter diameter pots, 5 seedlings per pot. Medium consists of a 1:1 peat: vermiculite mix maintained at a pH of 4.5.

3. Growing Environment[3]: Pots are kept at field capacity in a controlled environment for one week at:

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[2]Burdett, A.N. 1979. New methods for assessing root growth potential: their value in assessing lodgepole pine stock quality. Can. J. For. Res. 9:63-67.

[3]Recent evidence from the B.C. Ministry of Forests (Dr. W. Binder) suggests that the optimal environment for root expression in most coastal conifers is closer to 22°C/18°C (D/N). Our 1986 operational evidence using both environments confirms this, particularly for species with poor heat tolerance. However, improvement of prediction of outplant success (survival and growth) has yet to be proven.

30°C day temperature 400u einstein light intensity
25°C night temperature 75% relative humidity 16 hr photoperiod

4. Indexing: After one week each seedling is scored for root activity using the index developed by Burdett (1979.) These values are averaged to give a single value for each seedlot. The index is as follows:

Indexing Value	Number of New Roots	Indexing Value	Number of New Roots
0	none	4	11-30 >1 cm
1	some, none >1 cm	5	31-100 >1 cm
2	1-3 >1 cm	6	101-300 >1 cm
3	4-10 >1 cm	7	>300 >1 cm

RESULTS OF OPERATIONAL MONITORING AND PREDICTION OF OUTPLANT SURVIVAL

The following graphs illustrate how RGP of operational planting stock is related to operational and research outplant performance during 1984 and 1985. Note: RGP of 1.0 is currently considered the silvicultural soundness level. Plantation survival of 80 percent is the MB, Designed Forest plantation target.

1984/85 Operational Results

The shape of the RGP versus time curve (Fig. 1) illustrates the general case of RGP rising and then falling as planting stock progresses from lift through storage. Our operational evidence suggests that the positioning and shape of this generalized curve for any given season is dependent on species, seedlot, and cultural factors at the nursery level related to dormancy induction and hardiness. Chilling (natural and stored) may play a strong role in controlling RGP levels and timing.

Analysis of operational RGP testing and plantation performance data (Fig. 2) indicates that RGP can be used as a red light/green light tool for survival and that seedlings with some new roots, none >1 centimeter, would be a reasonable cutoff for sound planting stock.

Our ability to accurately predict outplant survival for seedlings exhibiting any number of new roots >1 centimeter is weak. For these seedlings, other physiological processes interact with limiting planting site conditions to influence seedling survival to a much greater degree than RGP.

1985 Common Garden Results

Douglas-fir seedlots were lifted February 15 and either planted or stored for 6 weeks or 21 weeks and planted. Outplantings were established in a non-irrigated, seed orchard field. The site was plowed to facilitate planting; vegetation was

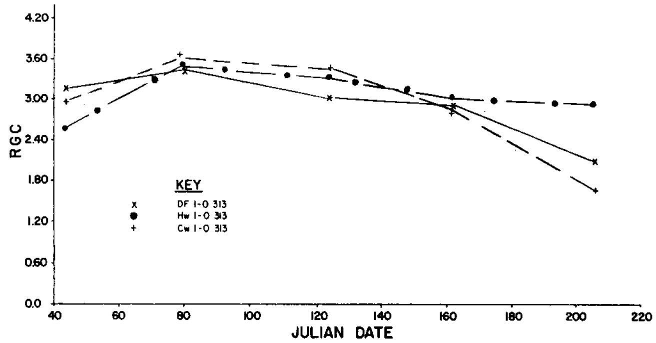

Figure 1. This figure illustrates the progression of root growth capacity in storage for three containerized coastal species: Douglas-fir, western hemlock, and western red cedar. All seedlings were lifted during the first week of February 1985.

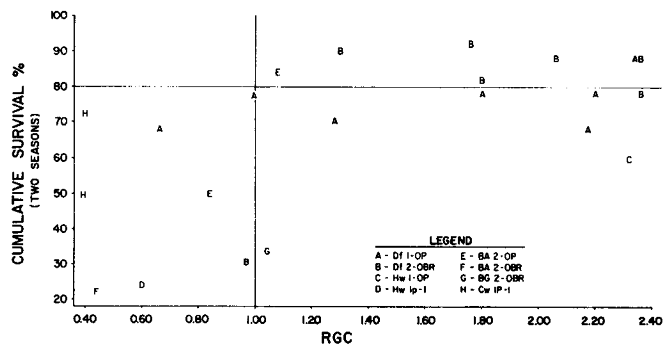

Figure 2. Plantation survival tends to drop rapidly for seedlots with no new roots >1 centimeter in most coastal conifers.

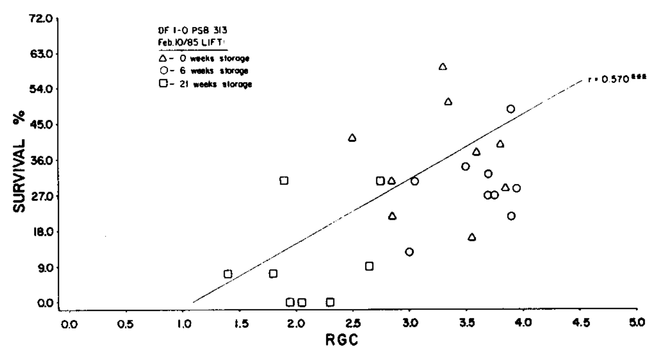

Figure 3. Containerized Douglas-fir seedlings exhibit high survival with high RGC and low survival with low RGC.

not controlled during the growing season. Seedlings were also potted and assessed for dormancy intensity under greenhouse conditions at each outplant date.

The outplant site and the 1985 growing season combined to provide severe drought for our test. Mortality was high but this provided a unique opportunity to assess the predictive powers of RGP and dormancy intensity under severe outplant conditions.

Figures 3 through 5 illustrate the relationships between RGP, dormancy intensity

[4]Dormancy Intensity = 10/number of days to budburst.

(DRI) and survival among a number of coastal Douglas-fir seedlots during 1985.

Within any of the three storage durations, RGP was a poor predictor of survival (Fig. 3). However, when considered as a group, seedlots with high RGP tended to survive better than those with low RGP. All seedlots had some roots greater than one centimeter in a one week-test (RGP = >1.0).

Survival was also reasonably well correlated with dormancy intensity (Fig. 4). Within a storage duration-planting date combination, those seedlings which burst bud rapidly consistently survived the best. This may be due to the fact that rapid initiation of growth (shoot and root) enhances a seedling's chances of occupying a larger rooting volume and capturing enough moisture and nutrients to survive through the rapid onset of drought.

To adequately determine the significance of this trend, we must expose a wider range of dormancy intensities to the same range of stresses. During the 1986 season, this hypothesis will be explored more fully under a range of moisture regimes.

Seedlings which burst bud rapidly tended to have low RGP (Fig. 5); however, as in the RGP versus survival relationship, no consistent trend existed among storage duration-planting date combinations.

CONCLUSIONS

- RGP assessment using the one week, 30°C/25°C (D/N) and Burdett's (1979) index method appears useful in identifying planting stock with a low probability of survival for a wide range of coastal species and stock types.

- An RGP value of 1.0 appears reasonable as a cutoff for silvicultural soundness to achieve a plantation survival target of 80 percent.

- RGP does not appear to have good predictive power beyond the roots/no roots determination.

- Evidence from Douglas-fir containerized stock suggests that stress resistance mechanisms related to cold hardiness and dormancy may play a significant role in seedling survival under stressful conditions.

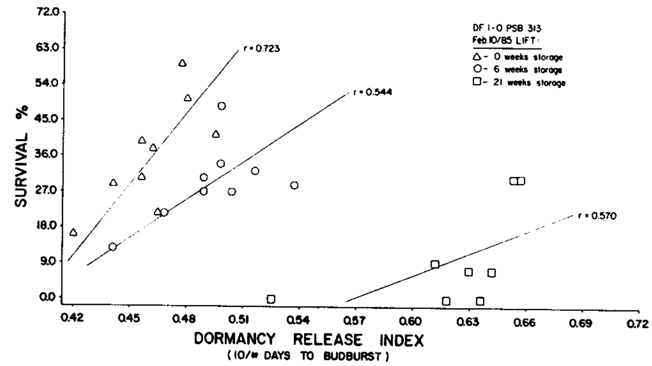

Figure 4. Under varying levels of outplant stress, Douglas-fir seedlings which burst bud rapidly tend to survive better than those which burst bud slowly.

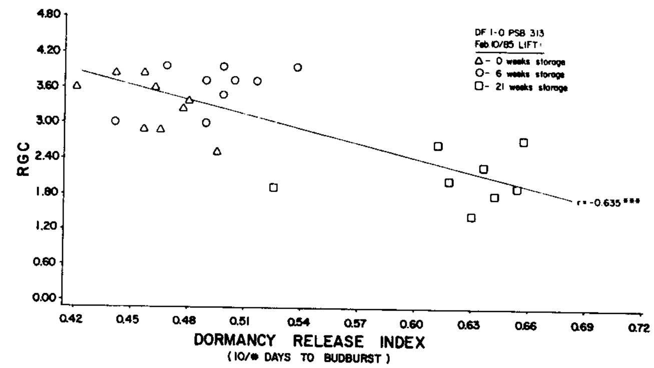

Figure 5. Containerized Douglas-fir seedlings which burst bud rapidly tend to have lower RGC.

- Challenge for the future is to use a more integrated approach to planting stock culture, allocation, and assessment by:

1. Developing a battery of stress resistance tests which accurately predict outplant survival and growth.

2. Using the battery of tests to provide an indication of stress <u>prior</u> to damage to facilitate preventative action and avoid batch culling.

3. Using test battery to improve nursery culture and seedling allocation through:

- reducing the frequency of low quality seedlots
- more adequately match seedling physiology to limiting site conditions.