METHODS OF STOCK QUALITY MONITORING FOR THE PRAIRIE PROVINCES

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ABSTRACT

Samples were taken from all seed lots of white spruce (*Picea glauca* (Moench) Voss) and jack pine (*Pinus banksiana* Lamb.) bare-root stock lifted during the fall of 1984 and the spring of 1985 at the four Saskatchewan forest nurseries. Half of the samples were placed in −2°C storage and half were placed in +2°C storage for 3 weeks. Root growth capacity (RGC) tests were conducted after 7 and 21 days, and RGC was determined by measuring new root elongation (RE) and counting the number of new roots (RN). Conditioning the seedlings at +2°C for 3 weeks prior to testing resulted in significantly higher RGC. The 21-day test resulted in significantly higher RGC. RE results are similar to RN results. The latter are preferred for ease of measurement. The 7-day RGC test is insufficient for testing bare-root white spruce and jack pine grown on the prairies. At the end of a 21-day RGC test, counting only new roots longer than 1 cm for white spruce may suffice, but all of the new white root tips should be counted for jack pine.

INTRODUCTION

Alberta, Saskatchewan, and Manitoba shipped over 45 million bare-root and container seedlings in 1986. Although it is important to ship sufficient numbers of seedlings in order to maintain adequate stocking in the field, it is of equal or even greater importance to ensure that seedlings shipped are of a high quality so that they will establish and grow rapidly in the field.

Several researchers have measured a range of morphological features in an attempt to relate some morphological quality to field performance. The principal attributes measured to quantify the morphological quality of nursery stock have been height, root collar diameter, height-diameter ratio, top and root dry weight, top-root ratio, root area, and volume. These factors are sometimes combined to develop an integrated approach to quantify morphological quality. The following are examples of this.

1. Quality Index (Dickson et al. 1960):

$$QI = \frac{SDW}{\frac{Ht}{RCD} + \frac{TDW}{RDW}},$$

where SDW is the seedling dry weight (g), Ht is height (cm), RCD is the root collar diameter (mm), TDW is the top dry weight (g), and RDW is the root dry weight.

2. Seedling Index (Armson and Sadreika 1979):

$$SI = \frac{Ht}{RAI} \times RCD^2,$$

where Ht is height (cm), RAI is the root area index (cm^2), and RCD is the root collar diameter (mm).

3. Quality Index (Iyer and Wilde 1982):

$$C = \frac{\sqrt{\frac{(x-h)^2}{(n-1)}}}{h} \times 100$$

$$QI = \frac{RCD}{Ht} + \frac{RV}{TV} + sg\ (stems) + CP + \frac{1}{C},$$

where C is the coefficient of variability, x is the height of individual seedlings (cm), h is the mean height (cm), n is the number of measured seedlings, RV is the root volume (cm^3), TV is the top volume (cm^3), sg (stems) is the specific gravity of the stems, and CP is the catalytic potential (dm Hg/plant).

These integrated approaches result in single values to which stock can be compared. Other researchers in Ontario (Scarratt and Reese 1976; Day 1985; Day et al. 1985) and in Oregon (Nicholson 1974) have developed size class standards based on a variety of morphological attributes.

Recently, terminal bud length (Thompson 1985) and the number of needle primordia in the terminal bud (van den Driessche 1984) have been used as measures to quantify morphological quality. These measurements may be indicators of potential growth the year after outplanting.

Classification of nursery stock using morphological characteristics is often not enough to predict outplanting performance. Many nurserymen and researchers are all too familiar with the case of planting stock with seemingly good morphological characteristics that belie expectations and die or perform poorly when outplanted.

The importance of the physiological quality of nursery stock was recognized in the 1940s by Wakeley (1948) who suggested that "a seedling's ability to resist excessive water loss, to take in water, and to extend its root system promptly might depend far less on its size and form than on its internal chemical or physiological condition—that is on its physiological grade." Ritchie (1984) similarly stated, "comparisons of seedling performance based upon morphological traits are valid only when seedlings are in the same physiological condition when tested."

The principal physiological attributes that have been used to predict outplanting performance in the field are root growth capacity, plant moisture stress, and vigor testing.

Although these measurements and tests have been conducted for several years and are used operationally as indicators for field performance in Ontario, British Columbia, and the Pacific Northwest, they have to be adapted and calibrated for specific conditions on the prairies (Navratil et al. 1986). Methodology and results for testing seedlings should not be taken from one region and used without modification in a second region.

METHODS

In 1985, five seed lots of bare-root 3 + 0 white spruce (*Picea glauca* (Moench) Voss) and three seed lots of 2 + 0 jack pine (*Pinus banksiana* Lamb.) stock were sampled from the four Saskatchewan forest nurseries (Table 1). Samples were taken from all seed lot-nursery-season combinations lifted during the fall of 1984 and the spring of 1985 with no duplications except for jack pine seed lot 1205018003 from Chitek Lake. Samples were taken for this seed lot from both thinned and unthinned beds.

Table 1. White spruce and jack pine seed lots sampled from the Saskatchewan forest nurseries in 1985

Species	Seed lot number	Seed lot	Nursery	Season lifted
White spruce	1	1207017801	Prince Albert	Fall
	2	1207017801	Prince Albert	Spring
	3	1309018001	Prince Albert	Fall
	4	1309018001	Big River	Spring
	5	1309018001	South Branch	Spring
Jack pine	1	1205018003	Chitek Lake (unthinned)	Spring
	2	1205018003	Chitek Lake (thinned)	Spring
	3	1205018003	Prince Albert	Spring

The samples were divided in half. Half were placed in frozen (−2°C) storage and half were placed in cold (+2°C) storage for 3 weeks. These storage temperatures were chosen because they are commonly used across the region.

Fifty seedlings from each storage temperature were selected for root growth capacity (RGC) tests. Twenty-five were tested according to the method used in British Columbia (7 days at 25°C days, 20°C nights) and 25 were tested according to the method used in Ontario (21 days at 24°C days, 18°C nights). The seedlings were potted, five per pot, in 15-cm bulb pans in a 3:1 peat and vermiculite mix. The experimental design was a 3^3 factorial randomized block design. There were five white spruce seed lots or three jack pine seed lots × 2 storage temperatures × 2 RGC tests × 5 replications × 5 seedlings/replication.

Root growth capacity was determined by estimating the number of small (<0.5 cm) and medium (0.5 to 1.0 cm) new white root tips in decile ranges and assigning a median length. The number of long (>1.0 cm) white root tips were accurately counted, and the accumulated length was measured.

All analyses were done on the Northern Forestry Centre's VAX computer using SAS programs (SAS Institute Inc. 1985). New root elongation (RE), new root number (RN), the elongation of new roots longer than 1 cm (LRE) and the number of new roots longer than 1 cm (LRN) were subjected to analyses of variance (ANOVA) (Steele and Torrie 1980). When ANOVA showed that there were significant differences between treatment means, a Student-Newman-Keul's test (SNK test) was applied to determine where these differences were (Steele and Torrie 1980).

RESULTS

In all cases, conditioning seedlings at +2°C for 3 weeks prior to the RGC tests resulted in significantly ($p = 0.0001$) higher RGC for each of the measured attributes (Table 2). The 21-day test resulted in significantly higher ($p = 0.0001$) RGC for each of the measured attributes (Figs. 1–12).

The results for the white spruce RGC tests are given in Figures 1–6. The RN results (Fig. 1) are similar to the RE results (Fig. 2). The LRN results (Fig. 3) are similar to the LRE results (Fig. 4). Generally, seed lots 2 and 4 had significantly lower RGC than the other seed lots. The effects of storage temperature are shown in Figures 5 and 6. There were no significant differences between the RGC test × storage temperature interactions for RE (Fig. 5). The 7 day, −2°C and the 7 day, +2°C RGC test × storage temperature interactions had significantly lower LRN than the other RGC test × storage temperature interactions.

Table 2. The effect of storage temperature on mean new root elongation (RE), new root number (RN), elongation of new roots greater than 1 cm (LRE), and number of new roots greater than 1 cm (LRC) for the 1985 RGC tests

Species	Storage temperature (°C)	RE (cm)	RN	LRE (cm)	LRN
White spruce	+2	28	64	11	4
	−2	19	52	5	3
Jack pine	+2	56	60	42	14
	−2	9	30	1	0

The results for the jack pine RGC tests are given in Figures 7 to 12. Again, the RN results (Fig. 7) are similar to the RE results (Fig. 8) and the LRN results (Fig. 9) are similar to the LRE results (Fig. 10). Seed lot 3 had significantly higher RE than seed lots 1 and 2 (Fig. 7). There were no significant differences between seed lots for any of the other attributes measured (Figs. 8, 9, and 10). The effects of storage temperature are shown in Figures 11 and 12. The 7 day, −2°C and 7 day, +2°C RGC test × storage temperature interaction had significantly lower RN than the other RGC test × storage temperature interactions (Fig. 11). The 21 day, +2°C RGC test × storage temperature interaction had significantly higher LRN than the other RGC test × storage temperature interactions (Fig. 12).

DISCUSSION

The 7-day RGC test is insufficient for testing bare-root white spruce and jack pine grown on the prairies. If all of the white root tips are counted and measured it may provide an estimate of RGC, but the results of the 7-day test should not be relied on too heavily.

The length measurement of new roots does not provide any more information than the number of new

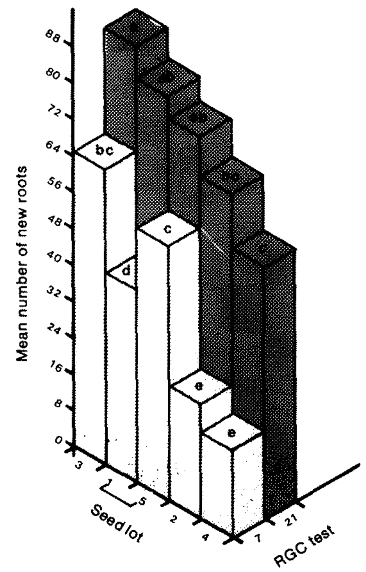

Figure 1. Number of new roots for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

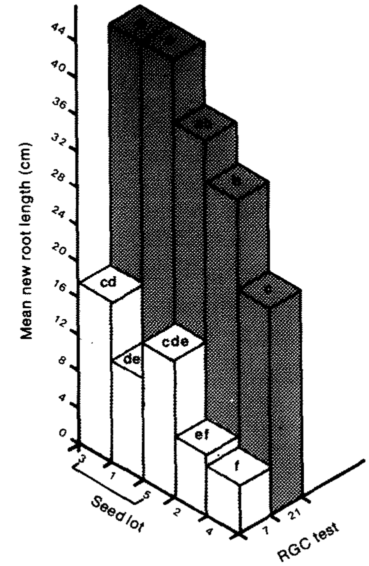

Figure 2. Length of new roots for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

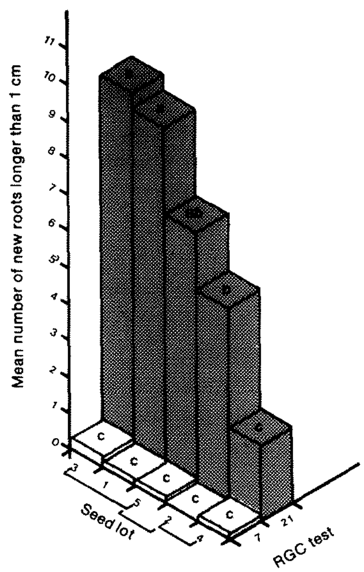

Figure 3. Number of new roots longer than 1 cm for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

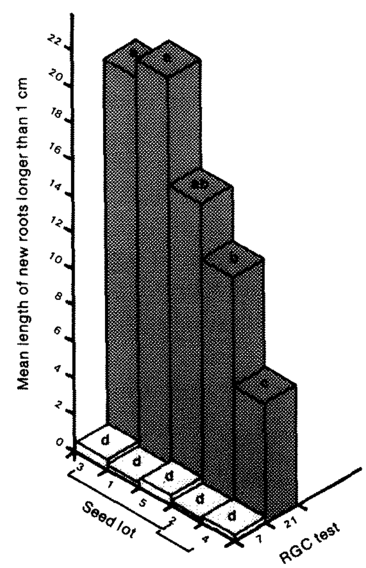

Figure 4. Length of new roots longer than 1 cm for white spruce RGC tests–seedlot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

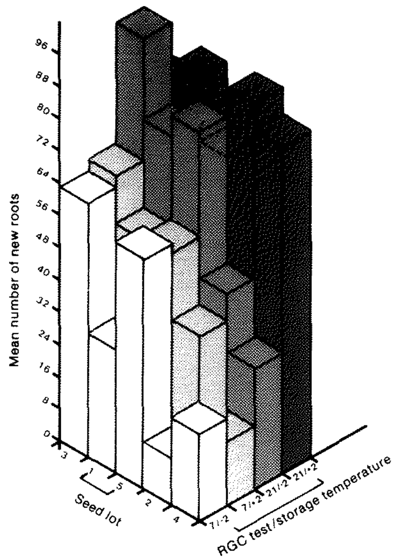

Figure 5. **Number of new roots for white spruce RGC tests–seed lot × RGC test × storage temperature.**

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line.

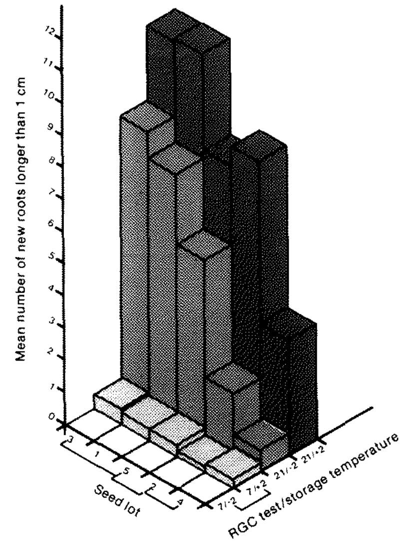

Figure 6. **Number of new roots longer than 1 cm for white spruce RGC tests–seed lot × RGC test × storage temperature.**

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line.

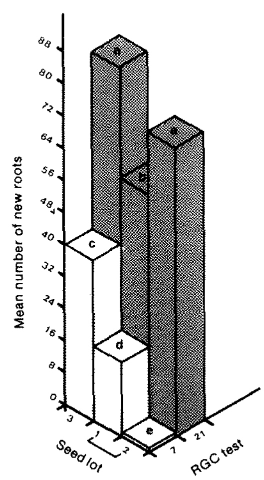

Figure 7. **Number of new roots for jack pine RGC tests–seed lot × RGC test.**

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

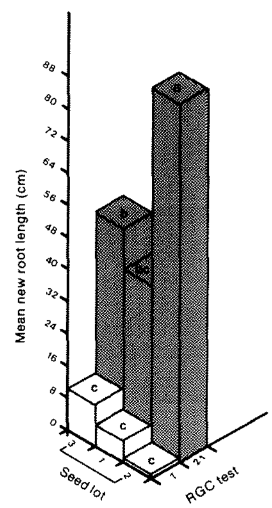

Figure 8. **Length of new roots for jack pine RGC tests–seed lot × RGC test.**

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

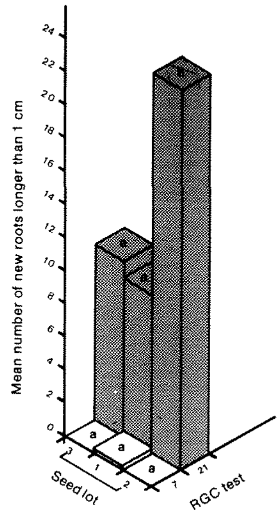

Figure 9. Number of new roots longer than 1 cm for jack pine RGC tests-seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

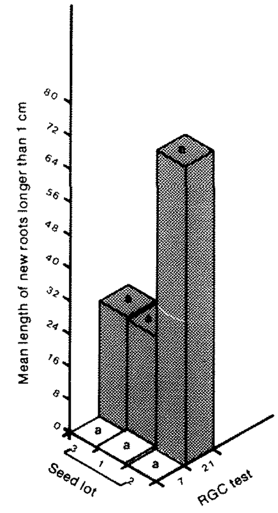

Figure 10. Length of new roots longer than 1 cm for jack pine RGC tests-seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

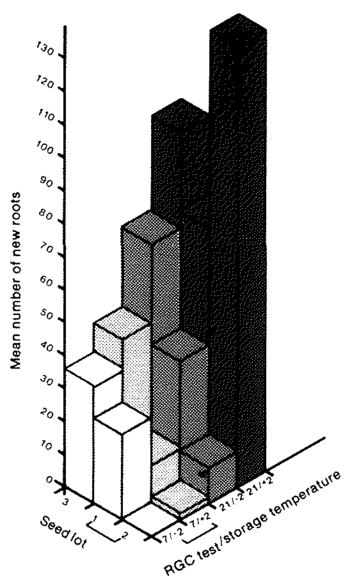

Figure 11. Number of new roots for jack pine RGC tests-seed lot × RGC test × storage temperature.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line.

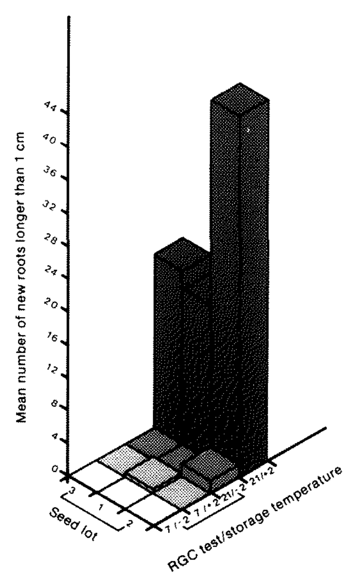

Figure 12. Number of new roots longer than 1 cm for jack pine RGC tests-seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line.

roots. Measurement of the former attribute should be dropped as it is extremely time consuming.

Counting the number of white root tips longer than 1 cm after 21 days may be sufficient for white spruce (Fig. 3) because these results are similar to counting all the new white root tips after 21 days (Fig. 1). A coding system such as Burdett's (Burdett et al. 1983) may therefore be used for white spruce after 21 days.

In order to achieve an accurate RGC test, all of the new white root tips should be counted for jack pine (Fig. 7). Counting the number of new roots larger than 1 cm does not provide an accurate assessment of RGC for this species (Fig. 9).

FUTURE MODIFICATIONS

Although a 21-day test appears to provide an accurate assessment of RGC, 3 weeks is too long to be operationally practical. A 14-day test should be tested in the future. Counting all of the new white root tips on a jack pine seedling can be extremely time consuming. Perhaps counting new white root tips longer than 0.5 cm would provide an accurate assessment of jack pine RGC.

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