COMPARISON OF SEASONAL ROOT GROWTH POTENTIAL OF 1-0 AND 2-0 EASTERN WHITE PINE SEEDLINGS

by

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ABSTRACT:-- 1-0 and 2-0 eastern white pine (Pinus strobus L.) seedlings were hand lifted on ten occasions from the Virginia Division of Forestry's Augusta nursery between October 15, 1985 and April 21, 1986. Following lifting, seedlings were subjected to a 21 day hydroponic Root Growth Potential (RGP) test. The two age classes showed significant differences in their pattern of RGP development and magnitude of new root production throughout the time period studied. The 2-0 stock showed a late autumn low that slowly increased to a very "narrow" late winter peak, while the 1-0 stock, which also experienced a late autumn low, maintained high levels of RGP from early January through mid March. Both age classes resumed low RGP levels with the onset of bud break. Possible explanations for these differences include: 1) a root pruned, 1-0 seedling has a much higher proportion of "new" suberized roots than a root pruned 2-0 seedling, and/or 2) RGP has been shown to be related to bud dormancy and an indeterminate 1-0 seedling apparently has a very different bud dormancy cycle than a determinate 2-0 seedling. Further research is needed to evaluate the feasibility of planting 1-0 eastern white pine, a practice which might be justified by it's much longer "lifting window", much higher root/shoot ratio, and the substantially lower cost of producing 1-0 seedlings.

ADDITIONAL KEYWORDS:-- Pinus strobus, RGP, bud dormancy, lifting window

INTRODUCTION

Initial survival after planting is largely dependent on a tree's physiological condition. This physiological status largely controls a seedlings ability to resume growth, both shoot growth and root growth. Root Growth Potential (RGP), a standard measure of the ability of a bareroot seedling to produce new roots, has been shown to be a good indicator of survival probability after planting and can be considered a general indicator of seedling vigor (Feret et al. 1984, Ritchie 1985).

Although there are typically differences between species and even between seed sources within species, a general seasonal trend in RGP tends to pervade. This includes: a late summer low,

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an increase in mid-autumn to a mid to late winter peak, and a sharp drop coinciding with renewed shoot growth in the spring. This pattern Is evidently strongly linked to bud dormancy and internal competition for carbohydrates between roots and shoots (Ritchie and Dunlap 1980).

Much work has been done studying RGP in the Pinaceae but until now no RGP studies have been reported using eastern white pine. A study was carried out to compare the seasonal pattern of RGP between 1-0 and 2-0 eastern white pine seedlings grown in a southern nursery. The study was initialized in preparation for later work that is scheduled to examine RGP in 29 half-sib families of eastern white pine using 1-0 stock. Knowledge of the relationship of 1-0 and 2-0 RGP may help in consideration of potential commercial ramifications due to genetic differences found using 1-0 stock.

MATERIALS AND METHODS

1-0 and 2-0 eastern white pine seedlings were hand lifted on ten occasions from the Virginia Division of Forestry's Augusta nursery between October 15, 1985 and April 21, 1986. On each lift date, a sample size of 45 was used per age class consisting of 15 seedlings randomly chosen from each of three pre-established blocks located within commercial nursery beds.

RGP was tested using a hydroponic system as described by Dewald et al. (1984). After 21 days of hydroponic growth, the following RGP data was collected from each seedling.

1. Total number of new short roots (> 0.5 cm. and < 1.5 cm.).
2. Total length of new long roots (> 1.5 cm.).

After RGP testing, the seedlings were rated by the following bud activity index as adapted from Jenkinson (1980).

1) Dead.
2) No apparent activity.
3) Terminal buds swollen.
4) Terminal starting to flush.
5) Terminal flushing with measurable elongation.
6) Terminal flushing with measurable elongation and needles flushing.
7) Already growing, often with no buds reset.

Seedlings from the January 3 lift date were also measured for dry weight of tap root, lateral root, needles, and stem, following drying to a constant weight at 60 C.

A two factor Anova was performed on the total length of new roots with age class and lift date as the factors of interest and with nursery blocks nested within age class. A Chi Square test was performed for each lift date to test the independence of bud activity index values on age class. Only values from seedlings alive at the end of the RGP test were included in Chi Square analyses.

RESULTS

RGP

1-0 and 2-0 eastern white pine seedlings showed considerable differences in their seasonal RGP development. Age, lift date, and the age*lift date interaction all proved highly significant ($P < .001$). The significance of the interaction term indicates that 1-0 and 2-0 stock showed substantially different seasonal RGP patterns. This is shown in Figure 1 where it is seen that 1-0 stock reached high levels of RGP in early January and maintained relatively high levels through March. Conversly, 2-0 stock tended to stay at low but steadily increasing levels through the winter until experiencing a sharp peak in mid-March. Both age classes showed relatively higher fall RGP levels that then dropped down to lowest levels In early December. Both age classes also showed low levels of RGP during April lift dates.

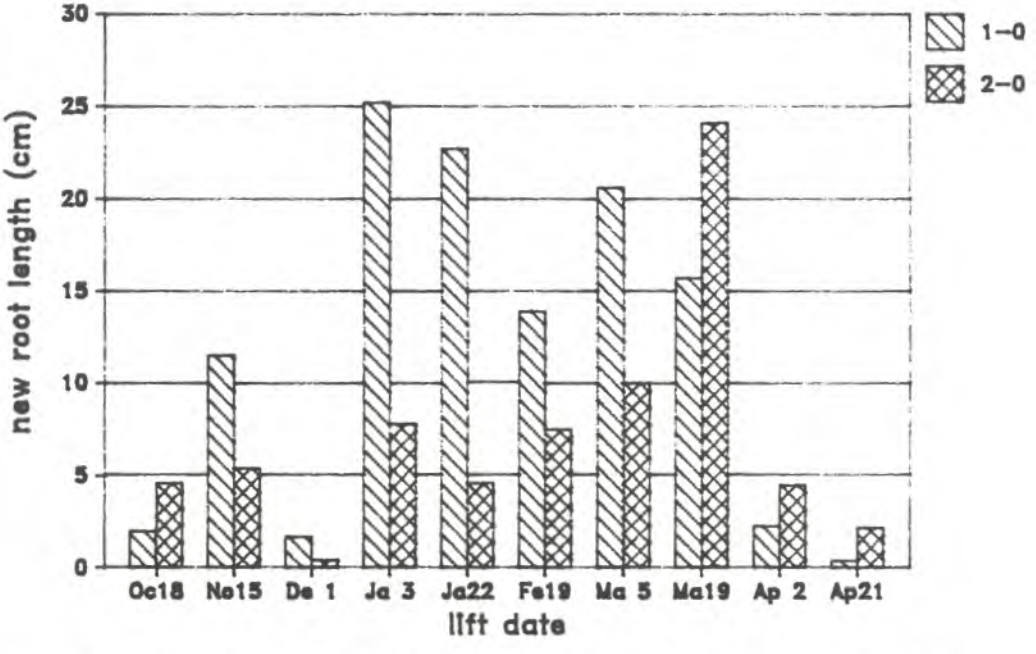

Figure 1. 1985-86 seasonal RGP of 1-0 and 2-0 eastern white pine hand-lifted from the Virginia Division of Forestry's Augusta nursery

Bud Dormancy

1-0 and 2-0 stock also showed considerable differences in their seasonal pattern of bud dormancy release as reflected in the change in mean bud activity index (Figure 2). 1-0 stock showed bud activity as early as December 1 and by February 19 terminal buds were flushing at the end of the 21 day RGP test. 2-0 stock maintained dormant buds until the March 19 lift date.

Based on Chi Square tests, bud activity index is dependent on age class from early December to early April with the exception of the January 3 lift date. Chi square and P values are shown in Table 1.

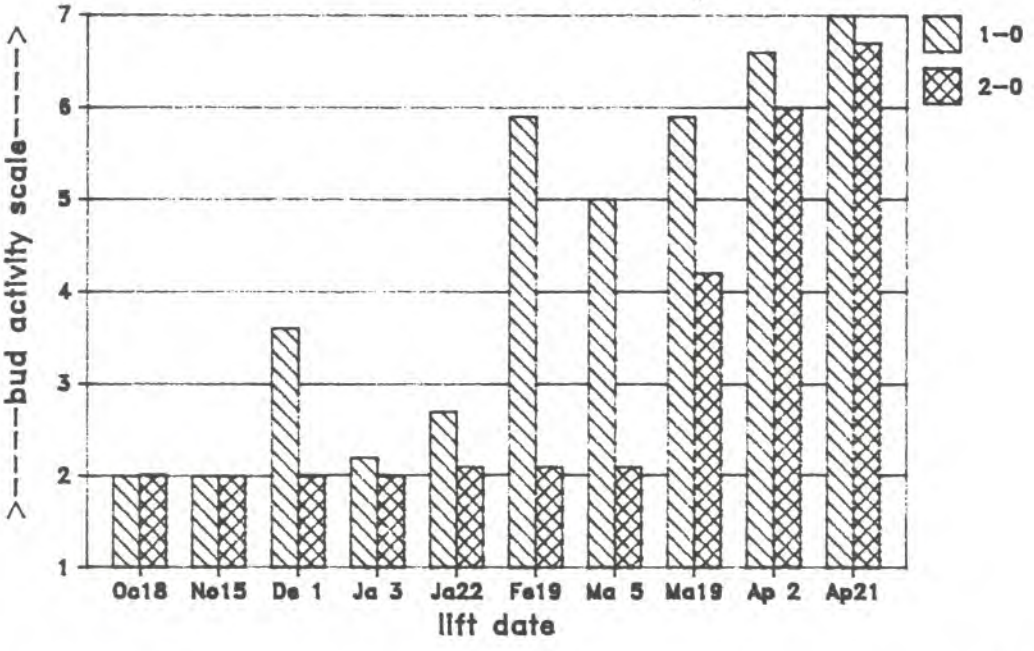

Figure 2. Mean bud activity index for 1-0 and 2-0 eastern white pine over 10 lift dates (as rated on living seedlings at end of 21 day RGP test)

Table 1. Chi Square and P values for test of independence of Bud Activity Index* on age class per lift date

	Lift Date									
	10/18	11/15	12/1	1/03	1/22	2/19	3/05	3/19	4/02	4/21
χ^2	0.0	0.0	14.7	2.0	13.5	85.0	66.1	59.3	22.6	8.7
P	1.00	1.00	.01	.85	.02	**	**	**	**	.12

* Bud Activity Index as described in materials and methods
** P < .001

Dry Weight

Mean dry weights and root/shoot ratios are shown in Table 2. In general, 1-0 stock stems, needles, and tap roots are approximately 18% the weight of those from 2-0 stock. The exception is lateral roots which are approximately 40% those of 2-0 stock. Lateral roots make approximately 47% of the total root weight in the 1-0 stock in comparison to 29% in a the 2-0 stock.

Table 2. Mean stem, needle, tap root, and lateral root weights from 1-0 and 2-0 eastern white pine lifted January 3

AGE	Stem (g)	Needles (g)	Tap Root (g)	Lateral Root (g)	root/shoot ratio (g/g)
1-0	0.24	0.69	0.097	0.087	1/5
2-0	1.36	3.82	0.530	0.213	1/7.4

Discussion.

In this study, 1-0 stock of eastern white pine had a substantially wider "lifting window" for high RGP and produced more new root length than 2-0 stock, when comparing peak RGP. At least two possible explanations for these differences can be hypothesized. They consider both the different root morphology and the different seasonal bud dormancy patterns of the two age classes.

At the time of RGP testing, seedlings are root pruned to a 12 cm length. Because of age a 1-0 seedling will only have roots that are one year old or less. A 2-0 seedling will have some portion of the root system that is up to two years old. The "newer" suberized roots of the 1-0 stock may have a higher capability to initiate and grow new white roots. This is substantiated since a comparison of peak values shows that 1-0 stock produced more new white root length than 2-0 stock but 1-0 stock did so with only 25% of the initial suberized root weight of a 2-0 seedlings.

Past studies have shown RGP to be highly related to bud dormancy and this experiment further substantiates this hypothesis (Ritchie and Dunlap 1980, Ritchie 1985). 1-0 seedlings both showed an ability to grow high levels of new white roots and demonstrate terminal bud activity much earlier than 2-0 seedlings when placed in a favorable environment. Since a 1-0 seedling starts from seed in the spring, it's primary growth is indeterminate. This is in contrast to the determinate primary growth of a 2-0 eastern white pine seedling which is limited by the number of leaf primordia formed the prior year.

The onset and release of bud dormancy is controlled by a myriad of external and internal stimuli. The process is poorly

understood but may include the production of growth regulators in the terminal bud and/or needles which are thought to influence RGP. A first year seedlings indeterminate growth, therefore, may be responsible for the different seasonal bud dormancy pattern and, consequently, the seasonal RGP pattern.

Both age classes had low RGP during the month of April when shoot growth was rapid. This was most probably due to an internal competition for carbohydrates where the shoot acted as a much stronger "sink" than the roots.

The results of this study point to the possibility of outplanting 1-0 eastern white pine. Besides it's much wider "lifting window", a 1-0 seedling also has the advantage of an increased root/shoot ratio. A 1-0 seedling has a root/shoot ratio of 1/5 compared to 1/7.4 of a 2-0 seedling. These figures are misleadingly low since lateral roots, where most new white roots are initiated, made up 47% of a 1-0 seedlings root system while lateral roots made up only 29% of a 2-0 seedlings root system. Also, 1-0 seedlings have a much higher RGP/shoot ratio than 2-0 seedlings, since top dry weight of 1-0 seedlings was only about 18% that of 2-0 seedlings but RGP maxima was roughly equivalent.

If 1-0 seedlings can be outplanted successfully, there is a final advantage in that they can be produced at a substantially lower cost than 2-0 stock. True costs will, of course, depend on survival rates and other factors such as necessary levels of weed control. Additional research is needed to further evaluate RGP of 1-0 eastern white pine, it's relationship to field performance, and the feasibility of outplanting 1-0 stock.

Summary

1-0 and 2-0 eastern white pine showed significantly different seasonal RGP patterns with 1-0 stock having a much longer period of high RGP. This appears to be related to the bud dormancy cycle as 1-0 stock showed bud activity, at the conclusion of the 21 day RGP test, months before 2-0 stock. This may be due to the indeterminate growth pattern of 1-0 eastern white pine seedlings. 1-0 stock also produced more new root length than 2-0 stock but with only 25% of the original suberized root weight, after root pruning. This is probably due to 1-0 stock having more "new" suberized roots that may have a higher capability to produce new white roots. The results of this study point to the possibility of outplanting 1-0 eastern white pine, a practice which might be Justified by it's longer "lifting window", higher root/shoot ratios, and the substantially lower cost of producing 1-0 stock.

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