ROOT GROWTH POTENTIAL OF LOBLOLLY PINE SEEDLINGS HELD IN COLD STORAGE UNDER DIFFERING MOISTURE TREATMENTS

Charles *J.* Barden and Peter P. Feret[1]

Abstract: Loblolly pine (Pinus taeda L.) seedlings were machine lifted on 13 January 1986 from the Westvaco Corporation nursery in Summerville, South Carolina and initial root growth potential (RGP) was determined. Seedlings were subjected to three different moisture treatments immediately prior to cold storage at 4° C in Kraft-Poly bags. Conditions were no added water (T-1), dipping the roots in water (T-2), and immersing the entire seedling in water (T-3) before storage. The storage durations were 2, 4, 8, 12, 16, and 20 weeks. RGP and moisture content of the seedlings were determined for each storage sample date. RGP as measured by length or number of new roots varied significantly by moisture treatment and storage duration, and the interaction was significant. The moisture contents of T-1 and T-2 seedlings were always lower, and RGP values of these treatments were consistently higher than T-3 seedlings. The results indicate that excessive moisture can have detrimental effects on the RGP of seedlings held in cold storage.

Additional key words: Pinus taeda, root growth capacity.

INTRODUCTION

Current regeneration practices in the South require periods of cold storage for most seedlings between lifting and field planting (Garber and Mexal 1980). It has been recognized that this storage period be as brief *as* possible to maintain seedling vigor (Menzies et al. 1985, Dierauf 1974, Dierauf and Marler 1969). Storage is necessary to arrest the natural progression of shoot activity in the spring. Successful plantings are often made up to late May in Virginia, but seedlings must be lifted by mid-March to prevent shoot growth in the spring. Also, clearing the nursery beds early in spring allows seed bed preparation to begin for the following crop (Garber and Mexal 1980). Cold storage has been shown to affect RGP in many studies (DeWald 1986, Feret et al. 1985; 1984, McCraken 1979, Jenkinson and Nelson 1978, Rhea 1977, Stone and Benseler 1962), but the effect has not been consistent. Various researchers have reported that RGP decreases, increases, or remains stable during periods of storage.

[1] Graduate Research Assistant and Associate Professor, respectively, Department of Forestry, 228 Cheatham Hall, V.P.I. & S.U., Blacksburg, VA 24061.

For species undergoing a true dormancy, the variable effects of cold storage can be explained by the following hypothesis (Ritchie and Dunlap 1980): A seedling shoot must be completely dormant prior to lifting and storage; this is usually quantified using a minimum chilling hour sum. Subsequent cold storage then often results in RGP increases. If a seedling is lifted at its dormancy peak, RGP usually is maintained in storage. However, if seedlings are lifted before dormancy has been achieved, or after the shoot is resuming activity, then RGP decreases in cold storage (Ritchie and Dunlap 1980).

The effect of cold storage is less predictable for species or seed sources with little or no chilling requirement, such as loblolly pine (Perry et al. 1966). Generally, loblolly pine seedlings do not store well until they are fully quiescent. In the Virginia Coastal Plain, this does not occur until late November (Dierauf 1982). Garber and Mexal (1980) reported loblolly pine increased its tolerance of storage until mid-December. Seedlings lifted before this time had low survival upon outplanting. However, lifting and storage after mid-December resulted in peak survival levels even after 9 weeks in storage (Garber and Mexal 1980). Another study by Dierauf and Marler (1969), though, showed survival and 3 year height growth decreasing for stored seedlings lifted after late December. Rhea (1977) reported similar results.

The duration and temperature of cold storage, in addition to lift date, can also have an impact on storage success. Prolonged storage at temperatures below -2 C results in freeze damage due to tissue dessication and cell rupture, while prolonged exposure to temperatures above +5 C results in rapid respiratory depletion of carbohydrates, and increasing fungal growth on the seedlings (Ritchie and Dunlap 1980). Within this -2 C to +5 C range, temperatures just above freezing are generally considered optimum. RGP has been reported to decline in loblolly pine even at these ideal temperatures (DeWald 1986, Garber and Mexal 1980). The length of time a seedling can maintain vigor in cold storage depends primarily on its current dormancy or quiescent status, and the environmental conditions in the storage unit. With these findings in mind, the objective of this study was to determine if the addition of different amounts of water to the seedlings prior to storage would effect their subsequent RGP levels.

METHODS

On 13 January 1986, 1-0 loblolly pine seedlings were machine lifted from the Westvaco nursery near Summerville, South Carolina, and shipped in coolers with ice to the Reynolds Homestead Research Center, in Critz, Virginia. The seedlot was an orchard mix intended for the South Carolina Coastal Plain. Seedling RGP was determined using a 24 day period in the greenhouse as outlined by Feret et al. (1985).

The initial RGP of the sample was determined before any storage treatments were begun. The seedlings were subjected to 3 different moisture regimes immediately prior to cold storage at 2°C in kraft-polyethylene bags. The moisture treatments were as follows:

1. No water was added to the seedlings (T-1);
2. Seedlings were dipped in water up to their root collar, taking care not to wet the foliage (T-2);
3. Seedlings were entirely immersed in water (T-3).

T-2 and T-3 seedlings were allowed to drip for 30 seconds before placing them in the storage bags. The storage durations were 2, 4, 8, 12, 16, and 20 weeks. Also at 2 and 4 weeks a fresh lift was obtained from the nursery (T-0), and its RGP determined. RGP of 15-16 seedlings was measured for each storage and moisture treatment combination. Also, moisture contents of a separate 15 seedling sample were determined gravimetrically for each treatment combination.

The data were analyzed as a 2 treatment factorial using analysis of variance. Correlation coefficents were determined between the RGP values and moisture contents. Duncan's New Multiple Range Test was used to determine if significant differences occurred due to treatments, and at what level.

RESULTS AND DISCUSSION

Total length of new roots and total number of new roots were highly correlated ($r = .96$, $p<.001$), so RGP is expressed only as length of new roots for this discussion. The initial RGP of the sample seedlings was 110 cm. RGP was significantly affected by the various moisture treatments and storage durations ($p<.01$). The moisture x treatment interaction was also highly significant ($p<.01$), due to very low RGP values in week 2, coupled with the high values in week 4 for T-3 seedlings (Figure 1). For every other storage duration T-3 seedlings ranked last. Large RGP fluctuations in stored seedlings have been reported elsewhere (Feret et al. 1984), and may be a response to stressful conditions, or may pattern natural RGP changes in the nursery (DeWald 1986). The latter appears to be true for these data (Figure 1).

The overall mean RGP of T-1 seedlings was the highest, although T-2 seedlings were not significantly different. T-3 samples had significantly lower RGP (Table 1). Hence, the addition of any water to the seedlings was not beneficial, and excess water was detrimental to RGP values. The moisture content of the seedlings following storage was negatively correlated ($r = -.45$, $p<.05$) with RGP, and was significantly different for each moisture treatment (Table 1).

This study suggests the addition of water to loblolly pine seedlings stored in closed kraft-poly bags is not beneficial, and excessive moisture is detrimental to RGP. The reduced RGP that T-3 seedlings expressed may have been due to the prolonged

TABLE 1. OVERALL MEAN LENGTH OF NEW ROOTS AND MOISTURE CONTENT OF STORED LOBLOLLY PINE SEEDLINGS.[1]

TREATMENT	NEW ROOT LENGTH (CM)	% MOISTURE CONTENT
T-1	78.15 A	65.21 A
T-2	76.27 A	69.66 B
T-3	56.85 B	73.82 C

[1] MEANS FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT AT THE .05 LEVEL.

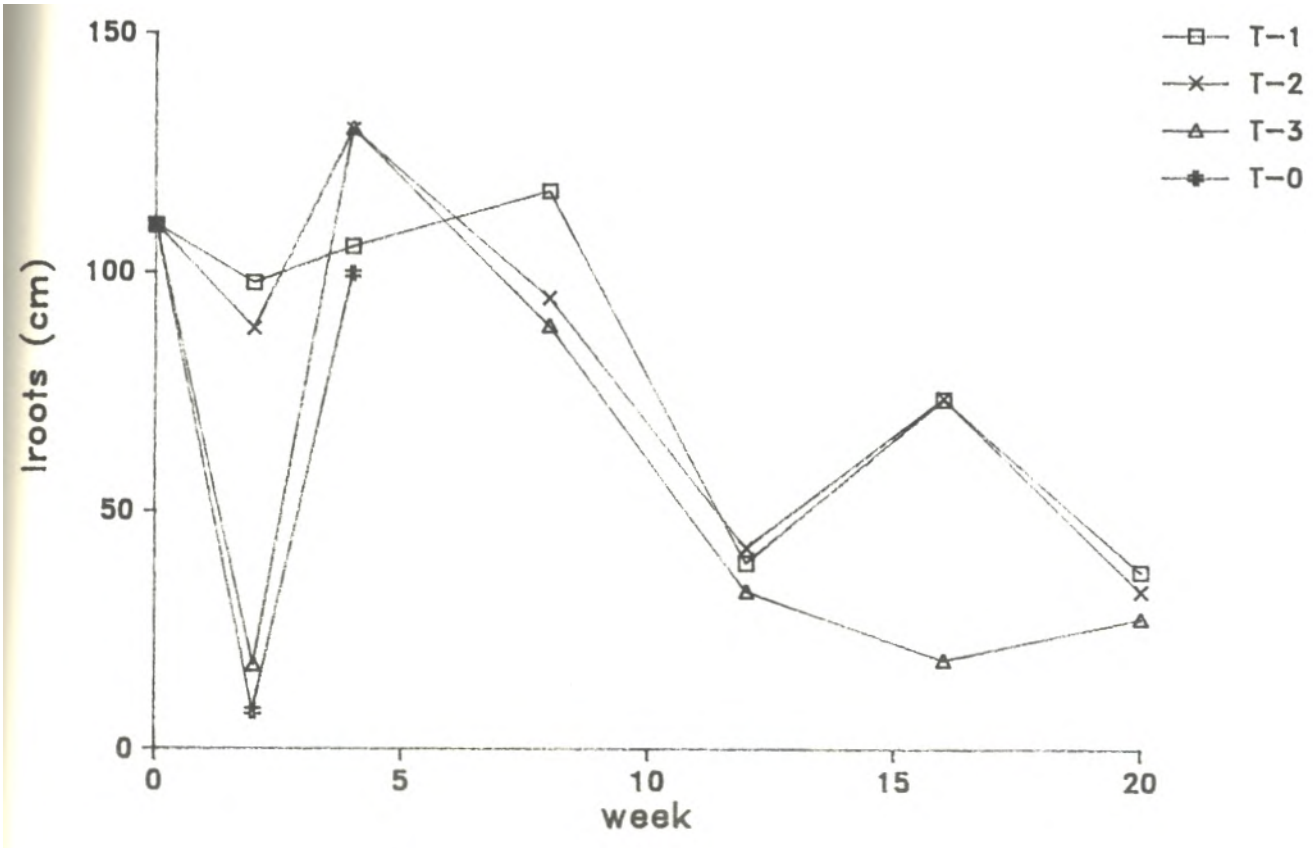

FIGURE 1. RGP (LENGTH) OF LOBLOLLY PINE SEEDLINGS OVER WEEKS IN COLD STORAGE, BY MOISTURE TREATMENT.

wetting of the foliage which occurred in the storage bags, possibly resulting in foliage degradation, even though no mold or fungal growth was obviously present. Data have shown strong correlations between % foliage removed and decreasing RGP values (Feret, unpublished data).

Another conclusion that can be drawn from these data are that seedlings lifted when their RGP levels are high, and stored under proper conditions, can maintain their vigor in extended cold storage. Even following 16 weeks in cold storage T-1 and T-2 seedlings averaged over 73 cm of new root growth. Thus, these seedlings were still in excellent condition. The inconsistent results of previous loblolly storage studies could be partially due to varying amounts of water in the storage environments. The practice of adding water or moisture holding materials to stored seedlings needs to be examined further, particularly when seedlings are held in closed containers.

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