Effects of Root-Coating With the Polymer Waterlock on Survival and Growth of Drought-Stressed Bareroot Seedlings of White Spruce (*Picea glauca* (Moench) Voss) and Red Pine (*Pines resinosa* Ait.)

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*Root coating with a superabsorbent polymer is a recommendable precautionary measure against drought-induced mortality in areas with frequent dry spells during the planting season. Root-coated white spruce (*Picea glauca *(Moench) Voss) exposed to no more then 2 weeks of post-planting drought showed a significant improvement of 24 percent in survival as compared to untreated seedlings. Root coating had not significant effect beyond 2 weeks of drought.* (Tree Planters' Notes 37(1):15-19; 1985)

Plantations established with bareroot seedlings in areas of periodic summer droughts are susceptible to increased drought-induced mortality rates (1, 3, 5, 8, 16).

Improvements in survival rates and growth of newly transplanted bareroot seedlings can be achieved by modifying the plant water balance. This is done either by reducing water losses through transpiration *(4,* 5, *20, 22)* or by facilitating water uptake *(14).* The latter is accomplished when the root system is provided with a sufficient and easily tapped water supply until the plant becomes self-sustaining.

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Dipping the roots of bareroot seedlings into a water-based gelatinous solution of a hygroscopic substance is a simple and inexpensive technique to provide plants with accessible water for the first critical weeks after planting *(2, 14).* In this paper, the effect of such a treatment on survival and growth of white spruce (*Picea glauca* (Moench) Voss) and red pine (*Pines resinosa* Ait.) bareroot seedlings are examined. Both species are widely used in reforestation programs throughout the Great Lakes region *(3, 24),* where recurrent warm and dry spells take their toll on newly established plantations. Although root-dipping with wetting substances has been known for many years in forestry (6), few critical studies have been made of the value of this treatment (7). The emergence of new superabsorbent polymers with improved absorption and retention capabilities calls for renewed evaluations.

Materials and Methods

A complete randomized block trial was established in May of 1984 on a sandy field at the Orono Forest Station, Ontario Ministry of Natural Resources (lat. 43°58' N., long. 78°37' W.). Treatment combinations (species x root coating x drought level) were replicated 3 times with six plants per replicate. .

The bareroot seedlings of white spruce (2 + 1) and red pine (2 + 0) were both of regional origin. The red pines were lifted in the third week of April 1984 and kept bagged in cool storage until May 9. The white spruce seedlings had been in cold storage since the end of October of 1983. Seedlings were planted manually on May 9 and were spaced at 0.3 x 0.3 meters within each plot. Initial plant sizes are listed in table 1.

Half the plants were treated immediately before planting by submerging their root system into a prepared gelatinous solution of Waterlock and water (1:160, w/w) Waterlock is a hydrolized starch polyacrylonitrile graft polymer potassium salt (Grain Processing Corp., Muscatine, IA). An average of approximately 100 grams of the gelatinous coating medium adhered to each treated plant.

Table 1—*Initial size of bareroot seedlings*[1]

	Age	Length (cm)	CV (%)	Diameter[2] (mm)	CV (%)
White spruce	2+1	27.3	19.1	6.2	22.5
Red pine	2+0	23.5	23.2	5.0	18.2

[1]CV = coefficient of variation.
[2]Measured 1 cm above the uppermost lateral root.

The drought treatments consisted of shielding the plants from natural precipitation for six different lengths of time following planting. To this end, lattice frames covered with transparent plastic foil were erected 1 meter above each plot. The slightly tilted (E-W) lattice roofs permitted passage of 50 percent of incoming radiation and had a 30-centimeter overhang on all plot borders. Encompassing each plot, a 50-centimeter-deep ditch lined with plastic collected runoff water and prevented root outgrowth from the plots. The rain shelters were removed 1, 8, 13, 19, 27, and 34 days after planting. Bud flushing and terminal leader growth were assessed weekly on all plots during the period from May 17 to July 3.

Xylem pressure potential measurements were taken on individual fascicles for red pine and on lateral branch tips for white spruce by use of a pressure chamber and handheld lens. Precautions were observed following recommendations of Ritchie and Hinckley (19). On selected days, midday xylem pressure potentials were taken on seedlings of each sample population from three additional plots established for this purpose.

All live plants were harvested on October 3, 1984, and their heights and root collar diameters recorded. Root and shoot dry matter contents were determined later. Plant dry matter was obtained after 48 hours drying at 80 °C in forced-air ovens. The significance of treatment effects (that is, root coating and drought) on dry-matter content, height, and shoot to root ratios was assessed separately for each species by means of two-way analyses of variance with frequency weighted means and interactions. Survival rates were compared on a logit-scale (3). Statistical comparison of bud release and height growth was done by means of an ordinary two-sample t-test for grouped data (3).

Results and Discussion

In treatments with less than 19 days of shielding from natural precipitation, root-coating significantly ($P = 0.05$) improved survival in white spruce seedlings by an average of 24 percent. Longer post-planting drought treatments reduced the positive effect of root-coating in white spruce to a non-significant level (table 2). The survival rates in red pine were exceptionally good regardless of treatment and were so nearly identical as to preclude any influence

Table 2—*Survival, height growth, dry matter, and shoot to root ratios of root-coated (R) and control (C) white spruce and red pine seedlings after 1 to 34 days of drought treatment (shielding from natural precipitation) after planting (May 9)*[1]

	1 day	8 days	13 days	19 days	27 days	34 days	Average
Rainfall received[2] (mm)	207	191	191	173	160	160	—
White spruce							
Survival (%)							
R	72ab*	78a*	83a*	67bc	61c	33d	66
C	60a	50b	50b	56ab	50b	39c	51
Height growth (cm)							
R	10.0a	8.3ab	7.3bc	6.7bc	5.0c	4.6	7.0
C	8.5a	8.1ab	6.8ab	7.3ab	5.4b	5.5	7.3
Dry weight (g)							
R	35.1	30.2	26.4	29.3	21.6	24.0	28.8
C	35.9	33.0	30.9	28.4	27.3	26.6	30.7
Shoot/root growth							
R	2.4	2.4	2.3	2.4	2.9	2.7	2.6
C	2.6	2.6	2.8	2.9	2.7	3.2	2.8
Red pine							
Survival (%)							
R	100a	100a	94a	94a	83b	89ab	94
C	94a	100a	94a	100a	83b	78b	92
Height growth (cm)							
R	11.5a	10.1abc	10.6ab	9.3abc	8.0bc	7.6c	9.5
C	12.9a	11.0ab	10.7ab	9.3ab	9.2b	8.4b	10.3
Dry weight (g)							
R	15.7a*	14.9a	12.5a	14.5a	10.1a	10.6a	13.0
C	20.3a	15.3b	13.2bc	10.6bc	12.1bc	9.3c	13.6
Shoot/root growth							
R	2.4b	2.6ab	3.1ab	2.9ab	3.3a	3.1ab	2.9
C	2.7b	3.0ab	3.1ab	3.1ab	3.7a	3.7a	3.2

[1]Treatment means (across rows) followed by a common letter do not differ at the 95% probability level, based on the "Studentized range" test (*23*).
[2]Rainfall received after removal of the rain shielding; data from the Orono Forest Station, May 9 through October 3.
*Significantly different from controls at the 95% probability level.

of root-coating (table 2). Neither species showed evidence of any simple relationship between survival and length of drought treatment. However, white spruce showed a distinct drop in survival in the longest drought treatment. The reason for the low survival rates in white spruce results from the low drought resistance of this species as compared to red pine (15, 17).

Height growth was significantly influenced by root-coating. In red pine, treated seedlings showed an average of 10 percent less growth than untreated seedlings (table 2). In white spruce, root-coating promoted height growth to a slight extent in those seedlings exposed to no more than 2 weeks of post-planting drought. Reverse effects were recorded in the longer lasting drought treatments (table 2). Root-coating did not significantly affect dry-matter content.

As expected, height growth and plant dry-matter content declined significantly with progressive duration of the post-planting drought treatment (9).

The ratio of shoot to root dry-matter content increased with the length of the drought period (table 2). This frequently observed reaction of drought stressed plants enhances the imbalance between water uptake and water loss through transpiration (11-13, 21, 23). Root-coating, on the other hand, lowered the ratio (table 2). The lowering of the shoot to root ratio has presumably contributed to the better survival of root-coated white spruce seedlings.

Plant water potential, measured at noon on three different days during May and June, showed no effect of root-coating. However, significant differences were found between species and between days (table 3). The higher values observed in the red pine seedlings reflect the better drought tolerance of this species (17). All water potential readings indicated a moderate to severe plant water stress common in transplanted seedlings at noon on warm, dry days (9, 10).

In white spruce, bud release and termination of height growth occurred 2 to 3 days sooner in the coated than in the untreated seedlings. Red pine, on the other hand, displayed no influence of root-coating on flushing or termination of growth. Table 4 lists flushing stages and percentages of total height growth on selected days in May, June, and July of 1984, The data are pooled across drought treatments due to the negligible impact of drought on bud release (18).

Table 3—*Midday plant water potential (MPa) of sheltered seedlings on 3 warm and dry days during the summer of 1984*[1]

	White spruce		Red pine		
Day	R	C	R	C	Mean
May 22	−1.72	−1.70	−1.15	−1.30	−1.47
June 5	−1.89	−1.81	−1.71	−1.53	−1.74
June 12	−2.14	−1.99	−1.49	−1.39	−1.75
Mean	−1.92	−1.83	−1.45	−1.41	−1.65

[1]R = root-coated seedlings, C = controls; standard error of difference = 0.1.

Summary

The effect of root-coating with the water-based, super absorbent starch polymer Waterlock on first-year survival and growth of transplanted bareroot seedlings of white spruce and red pine was assessed in a field experiment with six different periods of post-planting drought.

Root-coated white spruce exposed to no more than 2 weeks of post-planting drought showed a significant improvement of 24 percent in survival as compared to untreated seedlings. Over lengthy

Table 4—*Terminal bud release index (BRI) and percentage of total height growth (HG%) of surviving plants on different dates (May 7 to July 3) during the 1984 growing season*

Treatment[1]	May 17	May 22	May 28	June 5	June 12	June 19	June 26	July 3
White spruce								
BRI[2]								
R	0.8*	2.3*	3.8*	4.6*	5.0	—	—	—
C	0.4	1.8	3.3	4.2	5.0	—	—	—
HG%								
R	—	—	18.1*	47.9*	79.8*	85.3*	93.9	100.0
C	—	—	4.5	29.1	61.6	79.3	91.7	100.0
Red pine								
BRI[3]								
R	1.7	1.8	2.5	3.3	3.6	3.9	4.5	4.8
C	1.8	1.8	2.7	3.2	3.5	3.9	4.3	4.8
HG%								
R	—	—	—	29.4	66.5	71.6	79.7*	83.5
C	—	—	—	27.6	66.2	70.6	74.5	82.5

[1]R = root-coated seedlings, C = controls.
[2]0 = dormant, 1 = swelling, 2 = translucent bud scales, 3 = emergence of first needles, 4 = brush-like opening, and 5 = shoot elongation.
[3]0 = dormant, 1 = bud elongation, 2 = bud swelling and elongation, 3 = patchy wax deposits, 4 = emergence of short shoots, and 5 = shoot free to grow.
*Significantly different from controls at the 95% level.

periods of drought, root-coating no longer had a significant influence on the rate of survival. Survival in red pine was very high in both root-coated and untreated seedlings, with no significant effect of root-coating.

Root-coated seedlings of both species had lower shoot to root ratios than untreated seedlings, indicating comparatively better root growth.

Prolonging post-planting drought reduced growth significantly in all seedlings and increased the root to shoot ratio.

Readings of midday plant water potential showed the plants to be moderately to severely drought stressed, with no apparent effect due to root coating. Red pine had a significantly higher water potential than white spruce, indicating a better drought tolerance.

Bud release and termination of height growth occurred 2 to 3 days earlier in root-coated white spruce seedlings than in control seedlings. No such differentiation was observed in red pine.

It is concluded that root-coating with a superabsorbent polymer is a recommended precautionary measure against drought-induced mortality in areas with frequent dry spells in the planting season.

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