Root Exposure, Root Dipping, and Extended Spring Planting of White Pine Seedlings

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Abstract

A study was established to assess the effects of root exposure at time of planting on the performance of 3+0 white pine (*Pinus strobus* L.) seedlings. Stock was lifted weekly from April 22nd (1971) for 10 weeks, with and without root dipping in water, and exposed from 0-3 hours before planting. Survival, terminal growth (current leaders) and total heights were examined after five years.

Exposure resulted in damage; affecting survival, current growth and total height at five years. However, survival was unaffected by exposures of up to two hours on days with relative humidity above 80%. Dipping in water was found to be ineffective.

Extending the planting season with 'hot' planting (same day) resulted in reduction of terminal growth and total height. Survival was also reduced for dates following flushing.

Résumé

L'auteur étudie les effets de l'exposition des racines au moment de la plantation sur le rendement de semis 3 + 0 de pin blanc (*P. strobus* L.)

Le matériel était extrait du sol dès le 22 avril (1971) et sur une période de 10 semaines. Les racines étaient baignées ou pas, puis exposées à l'air pendant 0 à 3 heures.

Après 5 ans, on examina le taux de survie, la croissance terminale (flèches terminales) et les hauteurs totales.

Ainsi, une telle exposition entraîna des dommages, affecta le taux de survie, la croissance annuelle et la hauteur totale. Cependant, le taux de survie ne fut pas influencé par une exposition des racines de plus de 2 heures au moment où la température avait une humidité supérieure à 80%. Le trempage dans l'eau fut sans influence.

En prolongeant la période de plantation jusqu'aux jours chauds, on obtint une réduction sur la croissance de la flèche terminale et la hauteur totale. Le taux de survie fut également diminué pour une période postérieure au débourrage.

Introduction

In 1967 experiments were started at Midhurst Nursery, about 90 kilometres north of Toronto, to study the effects of 1) dipping the roots of the trees in water immediately on lifting and 2) exposure of roots to air drying for periods up to three hours. The liftings and plantings were scheduled for the same days and spaced at weekly intervals. Consequently it was possible to examine the effects of an extended planting season on bare-rooted freshly-lifted stock.

The initial experiment in 1967 was conducted with 3 + 0 white spruce (*Picea glauca* (Moench) Voss). A report based on the results to the end of the second year (Mullin 1971) showed improved survival and growth attributed to the wa-

ter dipping, increased damage resulting from prolonged root exposure, the injury being less severe on days of high relative humidity, and progressive inhibition in growth rate as the planting season extended.

The next experiment was conducted with 3 + 0 red pine (*Pinus resinosa* Alt.) in 1968. The fourth year results of this experiment have been reported with the fifth-year results of the spruce test (Mullin 1974a). In the red pine the dipping treatment was of no benefit except where the stock was subjected to prolonged exposure, whereas in white spruce dipping still showed benefit at five years. The red pine suffered losses commensurate with the duration of exposure, as did the white spruce, and both were influenced by the relative humidity during the exposure period. The red pine also showed a depression of height growth as the planting season advanced and, in contrast to the white spruce, a depression of survival rate.

The present report is concerned with the 1971 experiment with 3+0 white pine (*Pinus strobus* L.).

Procedure

To provide stock for weekly lifting randomized plots were laid out on regular 3 + 0 shipping stock beds. The 10 weekly liftings were carried out from April 22 to June 24 and thus extended the normal planting season by several weeks. In each lifting 200 trees were obtained from the designated plot in each of the five replications in the nursery (total 1000 trees). The trees were loosened by garden forks and pulled by hand. Upon lifting, the roots of half of the trees were dipped in water in the field, then packed in wet moss in wooden boxes. The remaining trees were packed in wet moss without dipping. The lifting was completed in the morning and the trees were immediately taken to the planting area, a distance of about 10 kilometres.

In the afternoon the trees for each replication were removed from the boxes and 100 trees each of the dipped and non-dipped lots planted immediately. At the same time 300 trees of dipped and non-dipped sources were placed on string nets (1.0 x 1.0 cm) in a plywood shelter which provided shade but not wind protection. This procedure was used to simulate exposure of roots as might occur in the shipping barn, in broken containers, or in excessive holding by

Table 1. Physical characteristics of the planting stock, 3 + 0 white pine, by date of lifting, spring 1971, basis 125 trees/date (25/replication).

Date of lifting and planting	Top length (cm)	Terminal length (cm)	Stem diameter (cm)	Oven-dry weight (g)	Top-root Ratio (in ODW)
1. April 22.....	15.8	1.6a	0.38a	5.15a	4.06
2. April 29.....	16.1	1.8a	0.40a	5.34a	4.15
3. May 6.....	18.3	2.0a	0.43a	6.03a	4.26
4. May 13.....	17.0	2.2a	0.41a	5.83a	3.66
5. May 20.....	17.5	2.6a	0.41a	5.59a	4.31
6. May 27.....	16.0	3.2a	0.43a	5.51a	4.02
7. June 3.....	17.8	8.2b	0.49b	6.36b	3.98
8. June 10.....	17.1	11.7c	0.50b	6.56b	4.16
9. June 17.....	17.5	18.0d	0.50b	6.79b	4.23
10. June 24.....	17.7	21.5e	0.55c	7.91c	4.08
Significance.....	NS	***	***	***	NS

NS = not significant

*** = significant at 0.1% level

Figures within column followed by same letter are not significantly different by range tests.

the planters. Shade was supplied because it could be made uniform throughout the experiment rather than counting on consistent sunlight for all planting dates. The remaining trees in the transfer boxes were used in the laboratory for characterization of the stock. After one hour of exposure on the nets 100 trees of each treatment were removed and planted (20 in each of five replications corresponding to those in the nursery beds). This was repeated at two and three hours. For each of the 10 dates a total of 800 trees were planted by the wedge method in cultivated soil.

The heights, length of terminals, and survival were obtained in the fall of 1975 at the end of the fifth growing season. In the analyses of variance the survival was analysed in terms of the angular transformation, the terminal and height data in terms of plot averages.

Results and Discussion

The trees used in the experiment were obtained from one seedlot unit and treated in the same manner on each date of lifting and planting, but phenological changes took place as the season advanced. The physical characteristics of the planting stock have been summarized in Table 1. The increases in leader-length (terminal growth in 1971), in stem diameter, and in oven-dry weight were all highly significant at the 0.1% level for the various lifting dates. Generally the upturn in growth occurred at Time 6 (May 27) about the time of flushing. There was no consistent change in the top-root ratio as the season advanced, in contrast to that found in other species (Lyr and Hoffman 1967; Mullin 1963).

Effects of Root Exposure. The effects of exposure, viz. control ('hot', direct planting) 1-hour, 2-hour and 3-hour, were highly significant in the analyses of fifth-year survival, terminal lengths, and total heights. In all these criteria the interaction of exposure with date of lifting was also highly significant. In other words, the effects of exposure were greater on certain dates of lifting than on others. This is illustrated in Figure 1

showing the survival percentages by time of lifting and by duration of exposure. Terminal lengths and heights show similar relationships.

The weather information for the period shows that on dates of lifting and planting when exposure damage was least, such as times 2, 6 and 7, the relative humidity was comparatively high.

Date of lifting	Relative humidity %
1. April 22	48
2. April 29	87
3. May 6	53
4. May 13	40
5. May 20	40
6. May 27	82
7. June 3	90
8. June 10	31
9. June 17	48
10. June 24	67

The relative humidity shown is the average for the three-hour period of exposure. No absolute threshold value is indicated but exposure of the roots of white pine during periods of relative humidity in excess of 80% appears to be reasonably safe. This is in accord with other studies; white spruce at 85% (Mullin 1971) and red pine at 80% (Mullin 1974a).

It was expected that on the earliest lifting (April 22) the roots would have been relatively dormant and hence damage by exposure would

Fig. 1. Fifth-year survival of 3 + 0 white pine nursery stock by date of lifting (and same-day planting), and by duration of exposure (Control, 1, 2 and 3 hours).

Table 2. Summary of the effects of exposure on survival, total height and current growth for white pine, white spruce and red pine.

	Period of Exposure				Significance
	Control	1-hour	2-hours	3-hours	
White Pine (5th year) Average of 10 plantings, weekly intervals					
Survival %.....	70.5	34.0	12.5	6.5	***
Height, cm.....	134.0	123.5	105.0	105.2	***
Terminals, cm.....	41.0	37.3	34.7	31.1	***
White Spruce (5th year) Average of 6 platings, weekly intervals					
Survival %.....	75.4	46.0	30.0	24.1	***
Height, cm.....	58.1	52.2	51.3	49.3	***
Terminals, cm.....	12.7	11.8	11.8	10.4	*
Red Pine (4th year) Average of 6 plantings, weekly intervals					
Survival %.....	47.7	31.3	18.3	13.5	***
Height, cm.....	80.9	78.7	77.3	75.0	***
Terminals, cm.....	29.2	28.6	28.4	28.4	*

* = significant at 5.0% level

*** = significant at 0.1% level

be small (Hermann 1967). However, with this species such was not the case (Figure 1). Obviously care and protection against any unnecessary root exposure is important from the earliest time of lifting.

Since the effects of exposure are highly significant in terms of survival, terminal growth, and total height at five years after planting nurserymen and planters should be aware of the lasting nature of exposure damage. This has been found to be true for all species studied in this series of experiments. The greatest relative losses from exposure, as indicated by survival and growth, were sustained by white pine, with white spruce being intermediate and red pine the least affected of the three species (Mullin 1971, 1974a).

Effects of Dipping. The dipping treatment in this series of experiments consisted of immersing the roots of the tree bundles (25 trees in each) in water for about 10 seconds immediately after lifting. The dipping was done in the field adjacent to the seedbeds and not in the shipping shed. The bundles were then packed in the field in wooden boxes containing wet sphagnum moss.

In the three analyses of the fifth-year data for white pine (survival, terminal lengths, and total heights) there were significant interactions of dipping with dates of lifting and duration of exposure.

The first interaction, dipping x date of lifting, is summarized in Table 3. This indicates that, although dipping had no measurable effect on survival rate, it may have had a slightly beneficial effect on growth in the early liftings and a depressing effect on growth in late season liftings.

The second interaction, dipping x duration of exposure, is summarized in Table 4. This illustrates that dipping of white pine at the time of lifting is of no benefit for normal handling (i.e. in the control, where all normal steps were taken to eliminate exposure) although it may improve survival rate if exposures of up to one hour are unavoidable.

To summarize the effects of dipping for the

three species it would appear that field immersion of seedling roots in water is of definite benefit for white spruce only. The treatment may also be of minor benefit for red and white pine under some conditions such as prolonged exposure. However, the possible inhibition of growth and survival from dipping during normal handling (controls) indicates that dipping should not be done for these species. The chief conclusion is that all possible elimination of exposure damage in red and white pine is much more important than dipping.

Extending the planting season. The performance of the control stock is an example of normal 'hot' planting (same day) of bare-root stock throughout and beyond the regular spring planting season. These results are summarized in Figure 2.

The survival rates for the individual plantings during the normal season (approximately to Time 5, May 20 in this location) were good and quite consistent, but subsequently showed some decrease. The average drop in survival rates from extended planting was about 4% per week.

In the growth pattern, however, both the terminal and total heights showed a progressive decline which was apparent right from the earliest planting. On the average delayed planting

Fig. 2. Fifth-year survival, total height, and terminal growth (current leader) of 3 + 0 white pine, by date of lifting for Control stock ('hot' planting — same day).

Table 3. Effects of dipping treatment by date of lifting on fifth-year survival, total height, and terminal growth; white pine.

Date of Lifting	Survival %		Height cm		Terminals m	
	Not dipped	Dipped	Not dipped	Dipped	Not dipped	Dipped
1. April 22.....	51.0	58.2	143.7	144.5	44.1	41.6
2. April 29.....	85.2	86.2	145.9	156.1	43.5	46.2
3. May 6.....	38.8	36.2	141.0	141.1	40.5	41.9
4. May 13.....	31.5	36.8	135.6	123.5	40.5	37.4
5. May 20.....	50.8	49.5	135.1	121.6	41.1	36.4
6. May 27.....	76.8	76.0	136.7	132.6	42.0	42.6
7. June 3.....	68.2	72.0	137.0	135.6	42.9	42.1
8. June 10.....	35.2	43.2	124.9	119.7	37.2	36.1
9. June 17.....	26.8	28.0	118.4	107.4	36.6	32.5
10. June 24.....	32.8	29.0	129.4	123.5	39.8	37.6
	NS		* Sig. Diff. = 9.6		* Sig. Diff. = 3.3	

NS = not significant

* = significant at 5.0% level

Table 4. Effects of dipping treatment by duration of root exposure on fifth-year survival, total height, and terminal growth; white pine.

Exposure	Survival %		Height cm		Terminals cm	
	Not Dipped	Dipped	Not dipped	Dipped	Not dipped	Dipped
Control.....	84.4	81.3	144.3	138.7	43.2	41.2
1-hour.....	51.9	63.2	135.5	132.9	41.3	40.1
2-hours.....	37.4	34.8	132.9	130.3	40.5	40.6
3-hours.....	26.1	26.8	120.8	128.8	38.6	40.3
	*** Sig. Diff. = 5.8		NS		* Sig. Diff. + 3.6	

NS = not significant

* = significant at 5.0% level

*** = significant at 0.1% level

accounted for a reduction of about 2.5% per week in total height and about 2.0% in terminal growth. Similar losses of growth have been found in the other experiments in this series (Mullin 1971).

For white pine therefore, early planting is recommended although it may be possible to plant too early under some conditions (Hermann 1965, Sutton 1969). Extended planting with fresh trees can be expected to produce inferior plantations. The use of properly packaged and refrigerated stock (lifted early in the season while still close to dormancy) may be considered as an alternative.

References

- Hermann, R.K. 1965. Survival of planted ponderosa pine in southern Oregon. Forest Res. Lab. Oregon State Univ., Corvallis. Res. Paper 2.
- . 1967. Seasonal variation in sensitivity of Douglas-fir seedlings to exposure of roots. *For. Sci.* 13(2): 140-149.
- Lyr, H. and G. Hoffman 1967. Growth rates and growth periodicity of tree roots. *IN International Rev. For. Res.* Vol. 2: 181-236.
- Mullin, R.E. 1963. Growth of white spruce in the nursery. *For. Sci.* 9: 68-72.
- . 1971. Some effects of root dipping, root exposure and extended planting dates with white spruce. *For. Chron.* 47(2): 90-93.
- . 1974a. Effects of root exposure of establishment and growth of outplanted trees. *IN International Symp. Ecol. and Physiol. of Root Growth.* Akademie-Verlag, Berlin. 229-242.
- . 1974b. Some planting effects still significant after 20 years. *For. Chron.* 50(1): 191-194.
- Sutton, R.F. 1969. Form and development of conifer root systems. *Commonwealth Forest Bull. Tech. Comm.* 7.