TESTS OF WATER AND CLAY DIPPING FOR FROZEN SPRING STORAGE OF WHITE PINE

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Neither clay dipping nor water dipping were beneficial in frozen storage or in direct planting of spring-lifted white pine.

Most of the work done to date on frozen storage of nursery stock has been concerned with overwinter storage (2). In this study, the possibility of lifting white pine *(Pinus* strobus *L.)* in early spring and holding in frozen storage was examined. Previous studies have shown the need for moisture protection in storage through the use of closed containers (7,8), therefore the Kraft-polyethylene bag was used. Water and clay dipping of roots before storage was also tested.

Table 1.—*Dates of lifting and planting White pine in 1973*

Liftings	Plantings						
	1	2	3	4	5	6	7
	April 24	May 7	May 23	June 5	June 19	July 4	July 17
April 17	X	X	X	X	X	X	X
April 30		X	X	X	X	X	X
May 15			X	X	X	X	X
May 28				X	X	X	X
June 12					X	X	X
June 26						X	X

Plots consisted of 75 trees stored vs 75 trees freshly dug and were replicated 5 times for each date of lifting.

Methods and Materials

In the spring and early summer of 1973, white pine seedlings were lifted for frozen storage at Midhurst Nursery and planted at intervals at the adjacent Midhurst Research Centre (table 1). The tests involved a series of seven liftings at 2-week intervals. Plantings were carried out in the alternate weeks, starting after 1 week of storage, and included a comparison with freshly lifted nursery stock (table 1) The unit plot at each planting consisted of 75 trees from storage and 75 control trees freshly dug (previous day or same day), replicated five times in a randomized block design for each date of lifting. There were 10,125 trees in the seven plantings. This procedure permitted examination of the effects of: (a) time of lifting; (b) duration of storage; (c) extended planting season, on both stored and fresh stock.

At each lifting the seedlings were tied in bundles of 25 and placed in Kraft polyethylene bags (KP) in the field. Lifting was controlled by a randomized plan superimposed on some of the regular shipping stock beds. Random samples were taken to the laboratory where 50 were measured at each lifting for both storage and fresh planting. Assessment of nursery stock at time of lifting is summarized in table 2.

A test of root dipping before storage was also included in this experiment. Three treatments were applied: (a) "no dipping" (ND) the trees were packed in KP bags with a handful of wet sphagnum moss, (b) "water dipping" (WD) the bundles (roots only) were dipped but not washed in a tub of water for a few seconds before being placed in a separate bag, and (c) "clay dipping" (CD) the roots in the bundles were dipped and agitated gently for a few seconds in a mud slurry This consisted of the local reddish-brown clay stirred in water. All bags were filled with normal loads before being put into storage. The storage chamber was pre-cooled to about minus 4^0 C and maintained at that temperature throughout the experiment.

The same three treatments were applied to the control stock (fresh-lifting to quick-planting) to provide "control, no dip" (CND); "control, water dip" (CWD); and "control, clay dip" (CCD). At the time of planting, samples of the three treatments were randomized in rows of 25 trees within the block of 75 trees assigned to control or to stored stock, for each time of lifting

The results of the experiment were examined in terms of the survival and terminal growth (current year's leaders of all living

Table 2.—*Stock measurements by dates of lifting, 3–0 white pine, Midhurst, 1973*

Lifting dates	Top [1] Length	Terminal [2] Length	Stem Diameter	Oven-dry Weight	Top/Root Ratio	Green Weight
	cm	cm	cm	g	ODW[3]	g
Apr. 17, Lift 1	22.8	0.9	0.48	7.34	4.23	17.24
Apr. 23, Control	27.9	1.4	0.53	7.76	4.21	20.65
Apr. 30, Lift 2	25.4	1.4	0.43	7.49	4.40	20.06
May 8, Control	28.5	1.8	0.46	7.94	5.24	24.08
May 15, Lift 3	25.8	3.6	0.53	9.12	4.70	24.84
May 22, Control	28.6	4.0	0.52	9.29	4.58	22.12
May 28, Lift 4	26.6	6.6	0.53	9.49	5.41	28.83
June 4, Control	27.0	10.6	0.53	9.54	6.88	25.55
June 12, Lift 5	26.3	16.6	0.55	8.98	6.22	32.91
June 19, Control	27.0	19.9	0.60	8.76	6.67	29.39
June 26, Lift 6	23.9	17.0	0.59	8.86	5.29	31.62
July 3, Control	27.9	21.1	0.66	11.75	6.00	33.92
— —						
July 17, Control	26.1	18.8	0.59	9.81	6.35	25.75

[1] To base of bud, includes 1972 growth
[2] Bud and shoot growth, 1973
[3] Ovendry weight

trees) at the end of the second season after planting, fall 1974. The last three plantings on June 19, July 6, and July 17 were failures and were not counted. Analyses of variance were performed for survival (angular transformation of percentages) and growth (approximate method for unequal-sized plots and by plot averages).

Results and Discussion

Previous studies show that successful cold storage requires large, well-balanced stock (6,7,9,10) The 3-0 seedlings used in this experiment (table 2) were very large but off-balance, the top-root ratio of over 4.2:1 being outside the working range of 1.8:1 to 3.8:1 of Armson and Carman (1). Hence the results of the storage may be below those that could be expected from higher quality stock.

The data in table 2 also show the growth in terminal lengths and stem diameter, and the irregular increases in weight and top-root ratio during the early part of the fourth year's growth. The early "peaking" of top-root ratio is similar to that previously found for white spruce (3).

Time of Lifting

The effects of the dates of lifting are summarized in table 3 in terms of survival and terminal length at the end of the second year. It is obvious that only the first lifting on April 17 was successful for frozen storage. By the second and later liftings there were serious losses in survival and growth. The last safe date for lifting would, of course, vary by location and by year. The spring in 1973 at Midhurst was slightly below normal in average temperature. The earliest lifting possible (closest to dormancy) is recommended for trees for frozen spring storage.

Extended Planting Season

We compared (table 3) stored stock (Lift 1 only) and fresh stock (Control) for use during the normal planting season (i.e., to about May 23) and the extended season (i.e., June 4 and later). At the first planting, the fresh stock was superior in both survival and growth. At the second and third plantings, stored and fresh stock were both reasonably satisfactory. By the fourth planting the stored stock was superior in both aspects. However, even if survival rates had remained reasonable, it was apparent that the rate of growth for the stored stock (although much better than the Control) had declined in both late and extended plantings. Similar results had been reported previously (7,9).

It appeared that this inhibition of growth would continue for some time (4). An extended planting season of white pine, even with stored stock, does not seem warranted.

Dipping roots in water or clay

The effects of dipping roots of bundled trees in water and in clay for stored trees (Lift 1 only) and for fresh trees are summarized in table 4. In the design of this experiment, the statistical analyses are valid within but not between plantings. However, for practical purposes the averages of survival and second-year terminals across the plantings are shown.

The "clay dipping" treatment produced significantly lower survival than "not dipping" on some stored and some fresh stock, and resulted in significantly lower terminal growth on some fresh stock. On the average, "clay dipping" resulted in the lowest survival and growth for both stored and fresh stock. It is not recommended for white pine.

"Water dipping" was similar to "no dipping" in terms of survival, but was significantly poorer in terms of growth at Plant 2. On the average, "water dipping" was slightly below "no dipping" in both survival and growth. In red pine *(Pinus* resinosa Ait.) and white spruce *(Picea glauca* (Moench) Voss) dipping in water became more advantageous as

Table 3.—*Survival (percentages) and terminal growth (centimeters) of 3–0 White pine at end of second year, by dates of lifting and planting*

	Survival			
	percent			
	Plant 1 (Apr. 24)	Plant 2 (May 7)	Plant 3 (May 23)	Plant 4[1] (June 5)
Lift 1, Apr. 17	59.5a	72.5b	69.9b	71.4c
Lift 2, Apr. 23		40.8a	37.1a	26.7a
Lift 3, May 15			36.3a	28.3a
Lift 4, May 28				43.2b
Lift 5, June 12				
Lift 6, June 26				
Control	81.3b	69.1b	67.5b	54.9b
	*	***	***	**
	Terminal Growth (1974)			
	centimeters			
	Plant 1	Plant 2	Plant 3	Plant 4
Lift 1, Apr. 17	14.2a	15.9b	12.2	11.5c
Lift 2, Apr. 23		12.6a	11.5	9.1b
Lift 3, May 15			10.5	9.3b
Lift 4, May 28				8.5ab
Lift 5, June 12				
Lift 6, June 26				
Control	16.9b	14.3b	11.0	7.0a
	*	**	NS	**

* = Significant at 5.0 percent level
** = Significant at 1.0 percent level
*** = Significant at 0.1 percent level

Items in vertical columns not followed by same letter are statistically different at 5.0 percent level or better

[1] Later plants were failures

the season advanced (5) but this did not apply in the case of white pine.

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Table 4.—*Results at end of second year by dates of planting, and by root dipping treatments in survival percentages and terminal growth in centimeters of 3–0 White pine*

Treatment	Plant 1	Plant 2	Plant 3	Plant 4	Average
			Survival		
Lift 1			percent		
ND	62.4	76.0	70.4	80.8b	72.4
WD	51.2	76.0	67.2	72.0ab	66.6
CD	64.8	65.6	72.0	61.6a	66.0
	NS	NS	NS	*	
Avg.	59.5	72.5	69.9	71.5	68.4
Control					
CND	80.8	80.8b	69.6	60.8	73.0
CWD	85.6	80.0b	72.8	46.4	71.2
CCD	77.6	46.4a	60.0	57.6	60.4
	NS	**	NS	NS	
Avg.	81.3	69.1	67.5	54.9	68.2
	*	NS	NS	**	
			Terminal Growth (1974)		
Treatment	Plant 1	Plant 2	Plant 3	Plant 4	Average
Lift 1			centimeters		
ND	13.4	17.0	12.6	12.2	13.8
WD	14.2	15.5	11.8	11.7	13.3
CD	15.0	15.2	12.3	10.2	13.2
	NS	NS	NS	NS	
Avg.	14.2	15.9	12.2	11.5	13.4
Control					
CND	17.2	15.5b	10.3	7.3	12.6
CWD	16.9	13.7a	11.8	6.5	12.2
CCD	16.6	13.4a	10.7	7.0	11.9
	NS	**	NS	NS	
Avg.	16.9	14.3	11.0	7.0	12.3
	*	**	NS	**	

ND = not dipped
WD = water dipped
CD = clay dipped
CND = control, not dipped
CWD = control, water dipped
CCD = control, clay dipped

* = Significant at 5.0 percent level
** = Significant at 1.0 percent level
*** = Significant at 0.1 percent level
Items in vertical columns not followed by same letter are statistically different at 5.0 percent level or better

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