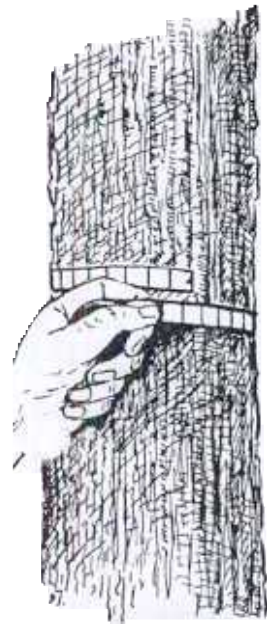
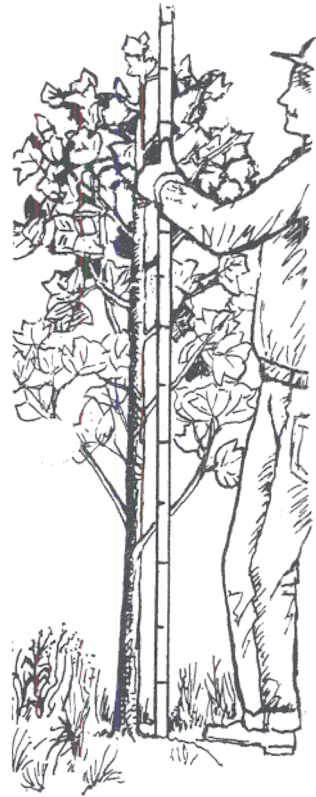
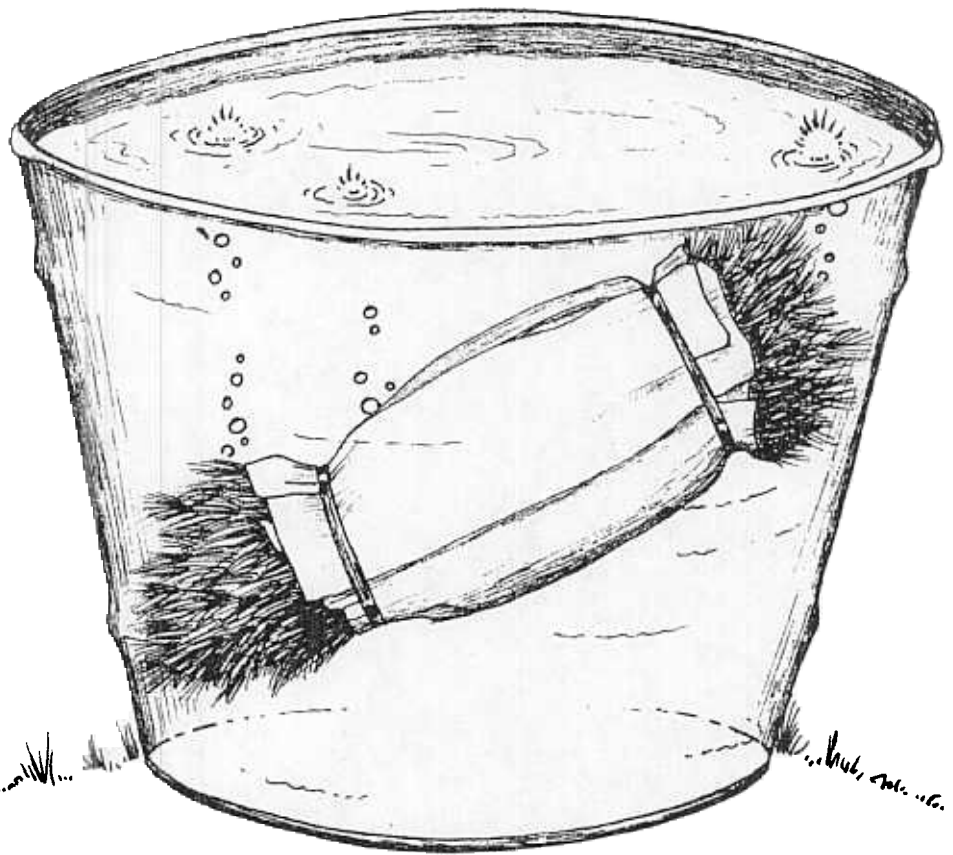


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# SEEDLING SOAKING



A THREE-YEAR STUDY OF IMMERSING STORED  
LOBLOLLY PINE SEEDLINGS IN WATER BEFORE PLANTING

T. A. Dierauf and L. C. Edwards

ABSTRACT

Survival of loblolly pine seedlings stored in unheated buildings from four to nine weeks improved five to eight percentage points when they were immersed in water for an hour before planting. Soaking for a day gave essentially the same results, but soaking for one or two weeks reduced survival drastically.

Brief immersion of seedling packages every two weeks during storage improved survival four percentage points in one year but reduced survival five points in another.

INTRODUCTION

Pine seedlings stored for a long period of time in barns, basements, and open sheds can be expected to lose considerable amounts of water. Similar studies were installed in 1979, 1980 and 1981, mainly to determine if a short period of immersing in water, just before planting, would improve survival of seedlings that had been stored for long periods of time in unrefrigerated storage buildings without humidity control.

We included unusually long soaking periods of one and two weeks in the first year's study, because there have been occasions when seedlings stored in basements or barns were unintentionally submerged for varying periods of time when storage facilities were flooded. In addition, it was learned that a contract tree planter had been deliberately submerging seedling packages in a creek to prevent dessication during temporary storage for periods of up to a week, and we are not aware of any problems with survival on tracts planted with seedlings stored in this manner.

The three studies were installed on or adjacent to the Pocahontas State Forest, which spans the fall line in central Virginia. The Coastal Plain soils are sandy, well to moderately-well drained, and nearly level to gently sloping.

## 1979 STUDY

### Procedure

Three packages of 1,000 freshly lifted seedlings were delivered to the Pocahontas State Forest on January 31, 1979. They were stored in an unheated garage for periods of 4, 6 and 8 weeks. The garage had several windows, so it was not dark during the daytime. At the end of each storage period, one of the three packages was opened and seedlings were selected for 4 treatments:

1. Planted immediately without any soaking
2. Immersed in a bucket of water for one hour and then planted
3. Immersed in a pond for one week and then planted
4. Immersed in a pond for two weeks and then planted

Seedlings for the four treatments were selected in the following manner. A 1,000 seedling package contains 20 bundles of 50 seedlings, each fastened with tape. One seedling was taken from each bundle to obtain enough for a 20-seedling row. This was done 12 times to obtain enough seedlings for twelve 20 seedling rows, three replications of each of the four treatments.

The first two treatments were planted on the same day the seedlings were taken from storage, and treatments 3 and 4 were planted one and two weeks later. The first planting was on March 1 and the last on April 12 (8 weeks storage in garage plus 2 weeks in pond).

### Results

Survival and height of each seedling were recorded for three years following installation of the study. Survival after three seasons is shown in Table 1. After six and eight weeks of storage, one hour soaking improved survival by 10 and 9 percentage points respectively. Immersing the seedlings for one week had no effect after 4 and 6 weeks of storage, but was very harmful after 8 weeks of storage.<sup>1/</sup> The 8 week storage period ended on March 29, and probably the seedlings had started to break dormancy (at our New Kent Nursery, seedlings in the seedbeds usually show signs of bud-break by about mid-March). This may explain the drastic decline in survival from the 6 week to the 8 week storage period. Two weeks of immersion was harmful even for seedlings stored only 4 weeks.

1/ Survival percents were transformed to arc sin and an analysis of variance was performed. The main effects of storage and soaking and their interaction were all highly significant (probability of larger  $F = 1.9 \times 10^{-8}$ ,  $7.6 \times 10^{-10}$ , and  $7.1 \times 10^{-5}$ , respectively).

Table 1. 1979 Study - Seedling Survival

<u>Garage Storage</u>	<u>Soaking</u>				<u>Means</u>
	<u>None</u>	<u>1 Hour</u>	<u>1 Week</u>	<u>2 Weeks</u>	
4 weeks	93	90	92	67	86
6 weeks	73	83	80	25	65
8 weeks	73	82	20	2	44
Means	80	85	64	31	

Average heights after three seasons are shown in Table 2. One week of soaking after 8 weeks of storage, and two weeks of soaking after all three storage periods, reduced height growth considerably.

Table 2. 1979 Study - Average Height in Feet.

<u>Garage Storage</u>	<u>Soaking</u>				<u>Means</u>
	<u>None</u>	<u>1 Hour</u>	<u>1 Week</u>	<u>2 Weeks</u>	
4 weeks	5.3	5.2	5.0	4.0	4.9
6 weeks	4.9	4.6	4.7	3.5	4.4
8 weeks	4.5	4.5	3.2	- *	
Means	4.9	4.8	4.3		

\* No average height is entered here because only one seedling survived of the 60 planted.

## 1980 STUDY

### Procedure

In this second study we tested soaking periods of one hour and one day, with the same storage periods of 4, 6 and 8 weeks. Because of problems with weather, the actual storage periods were closer to 5, 7 and 9 weeks. Seedlings were stored in the same garage as in the 1979 study.

We also tried supplemental watering during storage. For the 9 week storage period only, we had an equal number of additional packages that were watered every two weeks. Packages were immersed in a tub of water until they stopped bubbling, and then inclined so that excess water could drain out before they were put back in storage.

There were 12 treatment combinations: three soaking treatments (none, one hour, and one day) applied to four storage treatments (5 and 7 weeks, and 9 weeks with and without supplemental watering). Eight 1,000-seedling packages were used for the study, two packages for each of the four storage treatments. Seedlings for 20 seedling rows were selected in the same way as described for the 1979 study. In each of three replications, we planted two 20-seedling rows of each of the 12 treatment combinations; a row from two different seedling packages for each treatment.

Seedlings were lifted on January 29 and packed on January 30, 1980. Planting dates were March 6 and 7, March 17 and 18, and March 31 and April 1.

### Results

Survival and height of each seedling were recorded for three years following installation of the study. Survival after three seasons is shown in Table 3. One hour and one day soaking periods were equally good, and improved survival for all 3 storage periods by an overall average of about 7 percentage points. Supplemental watering every two weeks for the seedlings stored 9 weeks improved survival about 4 percentage points.<sup>2/</sup>

Table 3. 1980 Study - Seedling Survival

<u>Garage Storage</u>	- - - - <u>None</u>	<u>Soaking</u> <u>1 Hour</u>	<u>1 Day</u>	<u>Means</u>
5 weeks	88	96	99	94
7 weeks	88	98	98	94
9 weeks	87	92	92	90
9 weeks*	91	98	94	94
Means	89	96	96	

\* with immersing the packages every two weeks while in storage

2/ Survival percents were transformed to arc sin and two analyses of variance were performed. In the first analysis of variance the two week supplemental watering was omitted and the effects of none, one hour, and one day of soaking just before planting were compared over the three storage periods. Main effects of soaking and storage were both significant (probability of larger F = .00033 and .026 respectively), but their interaction was not (probability = .144). In the second analysis of variance the effect of the two week supplemental watering was tested for the 9 week storage period. The main effect of supplemental watering was significant (probability = .038) but the main effect of soaking and the interaction were not (probability = .242 and .709 respectively).

Average heights after 3 seasons are shown in Table 4. Treatments had no discernible effect on height growth.

Table 4. 1980 Study - Average Height in Feet

<u>Garage Storage</u>	<u>- - - - Soaking - - - -</u>			<u>Means</u>
	<u>None</u>	<u>1 Hour</u>	<u>1 Day</u>	
5 weeks	5.4	5.3	5.5	5.4
7 weeks	5.3	5.2	5.4	5.3
9 weeks	5.4	5.3	5.1	5.2
9 weeks*	5.2	5.5	5.3	5.3
Means	5.3	5.3	5.3	

\* with immersing the packages every two weeks while in storage

## 1981 STUDY

### Procedure

In 1981 we tested just the one hour soaking period prior to planting, and supplemental watering every two weeks for storage periods of 4, 6 and 8 weeks. Seedlings this time were stored in an open shed, instead of the garage used previously. There were 12 treatment combinations: 3 storage periods (4, 6 and 8 weeks) x 2 supplemental watering treatments (none and every two weeks) x 2 soaking treatments prior to planting (none and one hour). As in the 1980 study, two 1,000-seedling packages were used for each of the six storage combinations (weeks x supplemental watering). Seedlings for 20-seedling rows were selected in the same manner as before. There were two 20-seedling rows of each of the 12 treatment combinations, for a total of 24 rows in each of 3 blocks.

Three freshly lifted packages were delivered on January 29. Planting dates were February 25, March 12, and March 26.

## Results

As in the previous two studies, survival and height of each seedling were recorded each year for three years. Survival after three seasons is presented in Table 5. The one hour soaking before planting improved survival for all three storage periods, by an average of 3 percentage points for seedlings that received supplemental watering and 8 points for seedlings that did not. However, supplemental watering reduced survival for all three storage periods, with and without the one hour soak before planting; the average reduction was 5 percentage points.<sup>3/</sup>

Table 5. 1981 Study - Seedling Survival

<u>Shed Storage</u>	<u>Packages Submerged Every 2 Weeks</u>	<u>1 Hour Soaking</u>		
		<u>No.</u>	<u>Yes</u>	<u>Means</u>
4 weeks	No	81	96	89
	Yes	86	86	86
	Means	84	91	87
6 weeks	No	88	91	90
	Yes	81	88	84
	Means	85	90	87
8 weeks	No	81	88	84
	Yes	77	79	80
	Means	$\overline{79}$	$\overline{83}$	$\overline{81}$
<u>Overall Means</u>		82	88	

Average heights after three seasons are shown in Table 6. Treatments had no important effects on height growth.

<sup>3/</sup> Survival percents were transformed to arc sin and an analysis of variance was performed. The main effects of storage, supplemental watering, and soaking just before planting were all significant (probability of larger F = .056, .008, and .055 respectively), but none of the interactions were significant.

Table 6. 1981 Study - Average Height in Feet

Shed Storage	Packages Submerged Every 2 Weeks	1 Hour Soaking		Means
		No	Yes	
4 weeks	No	4.3	4.9	4.6
	Yes	4.8	4.5	4.6
	Means	4.6	4.7	4.6
6 weeks	No	4.5	4.9	4.7
	Yes	4.3	4.4	4.3
	Means	4.4	4.6	4.5
8 weeks	No	4.3	4.8	4.5
	Yes	4.2	4.5	4.4
	Means	<u>4.2</u>	<u>4.7</u>	<u>4.5</u>
Overall Means		4.4	4.7	

## DISCUSSION

Soaking seedlings for an hour just before planting was beneficial in all three studies. For seedlings that did not receive supplemental watering while in storage, the one hour soaking just prior to planting improved survival by 5, 7, and 8 percentage points in 1979, 1980, and 1981 respectively. This would be a simple and easily applied technique for improving survival of seedlings that had been stored in an unheated garage or shed for four weeks or longer. There seems to be considerable margin for error in the duration of the soaking period. Soaking seedlings over-night or all day would probably not be harmful based on these studies. However, immersion for a week or more should be avoided.

Supplemental watering of seedling packages every two weeks while in storage improved survival by 4 percentage points in 1980 but reduced survival by 5 percentage points in 1981. In 1980 we tested supplemental watering only for a 9 week storage period. In 1981 we tested it for 4, 6, and 8 week periods, and the survival reductions were 3, 5, and 6 percentage points respectively. Contrary to what we expected, supplemental watering did not become more beneficial with increasing time in storage.

We can offer no explanation for the opposite results in 1980 and 1981. As mentioned above, one hour soaking just before planting improved survival 7 points in 1980, and 8 points in 1981 for packages that did not receive supplemental watering. This similarity in results for 1980 and 1981 might suggest that moisture loss from the packages while in storage was similar in the two years. If this were the case, it is hard to understand why supplemental watering would be helpful one year and harmful the other. Even though watering packages while in storage would seem to be reasonable and sensible, these tests suggest that it might be safer not to do it.