Impact of Christmas 1983 Freeze on Growth and Survival of Slash, Loblolly and Longleaf Pine Seedlings from Alabama and Georgia Nurseries

by

S. J. Rowan 1/

Abstract

Outplantings of loblolly seedlings made before and after the freeze during Christmas 1983 indicate very little impact of the freeze on survival (1%) or growth. Slash pine is more susceptible to cold injury than loblolly and suffered greater losses in field plantings (survival - 44.8%). Field survival of longleaf seedlings, which are most susceptible to cold injury, was only 24.4%.

The early freeze of Christmas 1983 in the South is the second one on record to have caused such severe plant injury. The previous one occurred on and about December 16, 1740 (Plummer, G.L., University of Georgia, Institute of Ecology, personal comunication). At 1600 hours on December 24, 1983, temperatures across the Southern U.S. fell to below freezing and remained there until around noon on December 26, 1983. Wind chill equivalent temperatures (Table 2) reached well below 0 °F at many recording stations and caused severe damage to plants. Various climatological data for this period are presented in Tables 1,2,3,4, and 5 for future reference. Mr. Bill Padgett (Alabama Forestry Commission) called me during the first week of January 1984 to report that something was wrong with pine seedlings at the south Alabama Forestry Commission's Nauss nursery. His discription indicated that the problem was damage resulting from the Christmas hard freeze. As he and personnel of the

1/ Principal Research Plant Pathologist, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Carlton Street, Athens, GA 30602

Alabama Forestry Commission examined seedlings in all their nurseries, the picture of devastation began to unfold. Word of the damage spread like wildfire, and within hours the damage was being seen in nurseries from Texas to the Carolinas.

The cold injury-symptoms were seen as lesions primarily on tap roots but also on other large roots of seedlings. Lesion color ranged from red, orange, purple, and brown as the severity of injury increased. Cortex and xylem tissues beneath the lesions were corky to pithy, often with a tan or brown coloration on severely damaged seedlings; these tissues became necrotic and black with time. Histochemical and microscopic examination revealed that severely damaged seedlings (1) were physiologically different from undamaged seedlings, (2) sustained no visible cellular disruption and, (3) the damage extended through the cortex and into or beyond the cambium.

Inventories of injured seedlings led to several key conclusions: (1) Damage was more severe on the north than on the south side of east/west oriented beds. (2) Damage was genotypically controlled both within and between species of pine (Barbour 1981). (3) Damage was worse on green than on chlorotic seedlings (Levitt 1980). (4) Damage was worse on seedlings in a state of active growth than on cold acclimated seedlings. Lesions were formed in root areas previously described as likely to be metabolically active in late fall or early winter (Wahlenberg 1960; Kramer and Kozlowski 1979; Thimann 1957). The lack of injury to shoots of seedlings is probably because of the accumulation of a sufficient number of chilling degree-hours (Table 5) to cause the shoots to be acclimated before the cold arrived.

The question that everyone asked was, "What effect will cold injury of nursery seedlings have on their survival and growth in field plantings?".

No one knew, and numerous individuals made plantings in greenhouses and in the field to find out. In one greenhouse planting[1/] of loblolly seedlings from the Morgan Nursery near Byron, Georgia, seedlings were randomly selected from each of the eight drills from beds in each of five fields. After 2 months in the greenhouse, 95.3% of seedlings from the north drill survived and nearly 100% survived from the other drills (Table 6). Survival was nearly the same (98% vs 100%) in a separate study[2/] in which randomly selected seedlings from the same nursery were also grown in a greenhouse. In a third greenhouse test, however, only two thirds of severely damaged seedlings survived (Table 6).

Visual estimates of freeze damage at the Morgan nursery revealed some interesting facts (Table 7). Seedlings that had been top-pruned to 4" and 6" heights in early October had significantly less freeze damage than those top-pruned to an 8" height, not top-pruned at all, or those operationally top-pruned to an 8" height on two earlier year mowings. Apparently, the severe shock of mowing seedlings to 4" and 6" heights stopped growth and reduced freeze damage. A similar difference existed between chlorotic and green seedlings (Table 7) confirming previously published data (Levitt 1980; Li & Sakai 1981) that chlorotic seedlings are more resistant to cold injury. The shock of lifting and transplanting seedlings also stops growth and may have reduced the amount of injury to seedlings outplanted from the Morgan nursery before the freeze (Table 8).

[1'] is extended to David Bramlett, USFS, Macon, Georgia Research Center for use of these greenhouse data.

[2/] Appreciation is extended to Johnny Branan, Georgia Forestry Commission, Macon, Georgia for use of these greenhouse data.

Although field survival data (Table 8) are tentative because of the early (June) observations, survival of loblolly seedlings appears to be little affected by the freeze injury. Survival of slash and longleaf pines, however, appear to have been severely reduced by the cold injury (Table 8). A chemical analysis of roots of loblolly and slash pine from Morgan nursery graded into cold damaged and nondamaged classes showed that starch was reduced in cold-damaged slash but not in cold-damaged loblolly (Loblolly-not frozen: 23.1%, frozen: 29.4%; Slash-not frozen: 39.8%, frozen: 15.9%). Thus, poor survival should be expected in slash because of the reduced root starch alone. Height growth of all seedlings in the several outplantings did not differ in June observations, but it was probably too early for growth differences to have become evident.

LITERATURE CITED

Barbour, H. F. 1981. Loblolly seed source for west Kentucky. Proc. 1980 Southern Nursery Conf. USDA For. Serv. Tech. Pub. SA-TP 17, Nov. 1981: 15-23.

Kramer, P.J. and T.T. Kozlowski 1979. Physiology of woody plants. Academic Press, New York. 811 pp.

Levitt, J. 1980. Responses of plants to environmental stresses, Vol. 1. Academic Press, New York. 497 pp.

Li, P.H. and A. Sakai. 1981. Plant cold hardiness and freezing stress, Vol. 2. Academic Press, New York. 694 pp.

Thimann, K.V. 1957. The physiology of forest trees. Ronald Press Co. New York. 678 pp.

Wahlenberg, W.G. 1960. Loblolly pine. School of Forestry, Duke Univ., Chapel Hill, N.C. 603 pp.

Table 1. Minimum air temperatures recorded by the National Oceanic and Atmospheric Administration at various Southeast locations during Christmas 1983.

Date and location	Low temp. °F
25 December	
Stoneville, MS	4
Newton, MS	5
Poplarville, MS	8
Auburn, AL	3
Brewton, AL	6
Calhoun, GA	-2
Experiment, GA	0
Byron, GA	4
Savannah, GA	11
Tallahassee, FL	14
26 December	
Tifton, GA	9
Chipley, FL	10
Monticello, FL	11
DeFuniak Springs, FL	7

Table 2. Air and wind chill equivalent temperatures at four Southeast locations during Christmas 1983.

Date	Hour	Athens, GA		Macon, GA		Savannah, GA		Tallahassee, FL	
		Air	Chill	Air	Chill	Air	Chill	Air	Chill
12/24	1600	15	-20	24	- 6	39	23	39	18
	1900	10	-21	15	-10	30	10	24	- 2
	2200	8	-19	11	-18	22	- 3	18	- 7
12/25	0100	6	-23	9	-14	19	- 1	16	- 8
	0400	4	-24	8	-24	15	- 8	13	-15
	0700	3	-24	7	-24	14	-14	11	-12
	1000	9	-18	12	-10	19	- 1	15	-11
	1300	18	-11	20	- 7	26	5	23	0
	1600	20	- 7	24	- 2	28	10	27	8
	1900	15	-13	18	- 3	25	19	21	7
	2200	13	-11	15	-10	22	22	19	12
12/26	0100	10	-18	13	-11	19	15	19	12
	0400	9	-14	11	-13	18	11	19	15
	0700	9	- 5	10	-13	15	8	20	16
	1000	18	3	19	- 1	21	9	18	3
	1300	31	23	31	5	31	21	29	23
	1600	33	25	34	18	37	18	33	27
	1900	29	29	28	25	30	30	28	28
	2200	26	20	29	23	26	26	23	23

Table 3. Minimum soil temperatures (°F) recorded by the National Oceanic and Atmospheric Administration at a 4 inch depth at various Southeast locations during Christmas 1983.

	Date (December 1983)				
Location	24	25	26	27	28
Stoneville, MS	33	30	29	29	31
Newton, MS	41	40	40	33	32
Poplarville, MS	45	44	36	34	43
Auburn, AL	37	33	31	32	33
Brewton, AL	38	32	31	31	37
Calhoun, GA	38	35	32	32	32
Experiment, GA	43	38	36	36	36
Byron, GA	40	32	29	29	30
Tifton, GA	44	34	32	34	35
Chipley, FL	45	37	34	35	38
Monticello, FL	51	39	31	37	37

Table 4. Minimum soil temperatures (°F) recorded by the NOAA at each of several depths at various Southeast locations during Christmas 1983.

Location	Depth (in.)	Date (December 1983)				
		24	25	26	27	28
Stoneville, MS	2	29	24	24	25	31
	4	33	30	29	29	31
	8	33	31	30	30	29
Auburn, AL	2	35	27	27	30	33
	4	37	33	31	32	33
	8	39	34	32	32	33
Byron, GA	2	40	32	30	28	34
	4	40	32	29	34	35
	8	44	41	37	35	37
Tifton, GA	2	40	29	28	28	34
	4	44	34	32	34	35
	8	48	40	37	35	37

Table 5. Rainfall and chilling degree hours (< 46°F) recorded by NOAA at Macon, GA during October, November, and December 1983.

Date	Rainfall		Chilling degree hours		
	November (In.)	December (In.)	October (No.)	November (No.)	December (No.)
1	0	T			
2	0	0			9
3	0	.50			
4	.01	.30			
5	0	.48			
6	0	1.02		6	
7	.05	0			18
8	0	0			15
9	.01	0			12
10	.02	0			9
11	0	1.22		6	
12	0	.01		12	
13	0	0		9	
14	.54	.04		9	
15	.33	0			6
16	0	0		9	12
17	0	.09		12	6
18	0	.02		9	
19	0	T		9	9
20	1.89	0			6
21	0	.25		6	24
22	0	.78		9	15
23	0	T			24
24	2.98	0			24
25	0	0		12	24
26	0	0		12	24
27	0	.04		3	24
28	1.13	.69	9		6
29	0	.08	3	9	18
30	0	0		9	24
31	-	0			24
Total	6.96	5.52	12	141	333

Table 6. Survival of freeze damaged seedlings in greenhouse culture.

Species	Nursery source	Drill location	% Survival
Loblolly[1/]	Morgan (Random)	North - 1	95.3
		Mid - 2	98.4
		Mid - 3	100.0
		Mid - 4	100.0
		Mid - 5	99.2
		Mid - 6	100.0
		Mid - 7	99.2
		South - 8	100.0
Loblolly[2/]	Morgan (Random)	North - 1	98.0
		Mid - 4/5	98.0
		South - 8	100.0
Loblolly[3/]	Morgan (Damaged)	North - 1	66.7
Slash[2/]	Morgan (Random)	North - 1	66.7
Longleaf[3/]	Hauss (Random)	-	0.0

Appreciation is extended to David Bramlett, USFS, Macon, GA for data indicated by footnote #1 and to Johnny Branan, Georgia Forestry Commission, Macon, GA for data indicated by footnote #2. Data indicated by footnote #3 were generated from the author's greenhouse plantings.

Table 7. Effects of top pruning, chlorosis, and drill location on severity of freeze damage to pine seedlings in the Georgia Forestry Commission's Morgan nursery.

Condition	Severe damage (%)	Mild damage (%)	Total damage (%)
Pruned - Lob			
4"	0.0	4.6	4.6
6"	0.0	9.5	9.5
8"	1.5	43.5	45.0
Nur. Run	32.5	18.0	50.5
Check - unpruned	26.5	23.5	50.0
North drill - Lob			
Green	32.0	20.0	52.0
Chlorotic	0.0	4.0	4.0
Slash - North	60.3	30.9	91.2
Slash - South	16.0	24.3	40.3
Lob - North	25.6	14.4	40.0
Lob - Mid	5.5	4.5	10.0
Lob - South	6.5	3.5	10.0

Table 8. Early survival (June) of seedlings with differing degrees of freeze damage outplanted on several Georgia sites

Species	Damage (%)	Baldwin	Cedar Springs	Davisboro	Gracewood	Early County	Average
Loblolly	10	98.9[1/]	98.8	99.1	94.1	96.5	97.5
Loblolly	45	97.5[1/]	99.8	97.4	96.5	-	97.8
Loblolly	50	99.5[1/]	99.3	99.0	96.4	-	98.6
Loblolly	50 (NR)	-	99.2	97.6	95.3	94.5	96.7
Slash	40	-	-	-	56.5	-	56.5
Slash	90	-	-	-	44.8	-	44.8
Longleaf	10	80.0	-	-	-	-	80.0
Longleaf	100	24.4	-	-	-	-	24.4

[1/] These seedlings were lifted and outplanted before the Christmas freeze, whereas all others listed in the table were lifted and outplanted after the freeze.