EVIDENCE OF THE PRESENCE OF A LIFTING WINDOW FOR LOBLOLLY PINE NURSERY SEEDLINGS

Abstract.--On each of four lifting dates, in December 1979, and January, February, and March 1980, replicated bundles of loblolly pine seedlings were either outplanted after analyses for lipids, total sugars, and reducing sugars or cold-stored for future outplanting and chemical analysis. After 30 and 60 days, randomly selected seedlings were dug up from the field plots and analyzed for chemical components. Seedlings lifted in December and January survived and stored better than those lifted in February and March. No relationship existed between survival and the chemical components analyzed. The results suggest that there is a "lifting window" or period when loblolly pine seedlings survive better than at other times during the lifting season. Seedlings lifted during this period are more capable of surviving than seedlings freshly lifted later in the winter.

Additional keywords: Pinus taeda, chemical composition, survival, lifting season.

INTRODUCTION

In southern Coastal Plain nurseries, loblolly pine (Pinus taeda L.) seedlings are normally lifted between early December and early March or during the period between the first hard frost and when the beds must be cleared and prepared for the new seedling crop. Seedlings are normally considered to be cold hardy between mid-December and February, but, because of the unpredictable weather patterns in the Coastal Plain, a distinct, continuous dormant season may not exist. Because it is difficult to visually determine whether a seedling is physiologically dormant, the best estimate of seedling dormancy has been to wait until the first hard frost occurs. This is perhaps a practical approach, but it also is uncertain and will not allow for optimal management. Truly dormant seedlings may occur for only a short time during the lifting season.

Successful plantation establishment requires high seedling survival and early initiation of both shoot and root growth to overcome weed and brush competition for water and sunlight. Seedlings outplanted early in the season (i.e., in December) should begin vigorous shoot growth as soon as favorable conditions develop in the spring because they will have had between 2 and 3

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months to adjust to the environment. Seedlings planted early in the season are expected to develop better root contact with soil than seedlings planted at the end of the winter because rains will have silted in the air pockets left around the roots. This should increase the probability of survival. Furthermore, seedlings planted at the beginning of the season should have more time for new root regeneration because root growth often continues during much of the winter in the southern Coastal Plain. However, if root regeneration does not occur immediately following outplanting, then seedling establishment potential may be lower for seedlings planted at the beginning of the dormant season, since the seedlings probably expend much of the stored energy reserves to survive the dormant season.

The purpose of this study was to determine the effects of lifting date and storage interactions on the survival of loblolly pine seedlings.

MATERIALS AND METHODS

The loblolly pine seedlings used in this study were grown at the W. W. Ashe Nursery in Brooklyn, Mississippi, in four 50-foot-bed sections. In July 1979, they were thinned to 27 seedlings per square foot. All of the seedlings were undercut and laterally root-pruned on October 15, 1979.

The seedlings were classified as Grade 1 or 2 according to Wakeley (1954) and were lifted from a single Louisiana loblolly pine seed source. The roots of seedlings designated for either immediate planting or cold storage for a later planting were sprayed with a kaolin clay slurry, and the plants were packed in kraft-polyethylene bags within 1 hour after lifting from the nursery beds. The seedlings were lifted on December 15, 1979; January 8, 1980; February 9, 1980; and March 10, 1980. On each lifting date, replicated bundles of seedlings were 1) put into cold storage for analysis of chemical contents on each of the subsequent lifting dates, 2) outplanted concurrently with seedlings cold-stored on each of the previous lifting dates, or 3) analyzed for chemical contents. Simultaneously with planting, previously planted seedlings were dug up on each of the planting dates and analyzed for chemical components. The seedlings were planted at a 2 x 2 foot spacing in central Louisiana in completely randomized design. Treatments were replicated 4 times with 50 seedlings per treatment row.

Seedlings designated for chemical analysis were lifted, and the roots were washed free of soil and packed in ice at the nursery beds or at the field site and transported to the laboratory where they were freeze-dried and ground for chemical analysis. Concurrently with the planting regime, seedlings were analyzed for lipid content to determine if there was any relationship between total lipid content and survival. Analyses were run separately for the shoots and needles. Lipids were extracted in boiling ethyl ether for 8 hours. The residue of this extraction was weighed and converted to percentage of lipid per dry weight of either root or shoot tissue. The data collected reflect the mean of two extractions. The bulk residue was then extracted to determine the percentage of total and reducing sugars (Nalewaja and Smith 1963).

In this study, all of the seedlings were outplanted or analyzed for chemical components within 2 to 4 days of the 0-, 30-, 60-, 90-, or 120-day treatment dates.

Lipids

Lipid concentrations in the tops of December-lifted seedlings decreased from 21 to 13.4 percent of the dry weight over the 120 days following outplanting in December 1979 (table 1). Lipid contents of seedlings lifted on December 15 decreased from 21 percent to 9.7 percent during cold storage for 90 days. This represented about a 55 percent decrease in lipid contents. Lipid contents of the December-lifted seedlings that were cold-stored before outplanting remained fairly constant following outplanting, while seedlings lifted and planted immediately showed a decrease in lipids with time in the field.

Table 1.--Percentage of lipids in loblolly seedlings after lifting at monthly intervals between December 15, 1979 and March 10, 1980

Date lifted	Days of cold storage	Days after field outplanting: 0	30	60	90	120
		% lipid of dry weight				
Shoots						
Dec. 15, 1979	0	21.0	17.8	17.7	16.2	13.4
	30	10.7	13.4	12.1	9.2	----
	60	9.8	9.2	12.3	----	----
	90	9.7	12.6	----	----	----
Jan. 8, 1980	0	11.8	11.5	11.6	15.6	----
	30	9.4	15.2	16.9	----	----
	60	15.6	16.9	----	----	----
Feb. 9, 1980	0	9.0	18.0	17.5	----	----
	30	8.2	14.4	----	----	----
Mar. 10, 1980	0	9.6	15.4	----	----	----
Roots						
Dec. 15, 1979	0	7.9	8.8	8.0	9.7	4.4
	30	8.0	4.8	10.0	8.0	----
	60	5.2	6.2	8.0	----	----
	90	4.2	4.1	----	----	----
Jan. 8, 1980	0	5.3	6.0	7.8	5.8	----
	30	8.0	5.6	7.1	----	----
	60	3.8	10.0	----	----	----
Feb. 9, 1980	0	9.4	6.4	5.8	----	----
	30	4.2	10.8	----	----	----
Mar. 10, 1980	0	5.0	6.0	----	----	----

Lipid contents of the tops of seedlings lifted in January were lower than those of the tops lifted in December (table 1). These concentrations remained fairly constant over the sample times following outplanting. Seedlings lifted and cold-stored for 30 days began to produce lipids immediately after outplanting, as reflected by the 30 percent increase in lipid content. However, seedlings cold-stored for 60 days did not show any further increase in lipid contents.

Lipid contents of seedling tops lifted in February were constant through 30 days of cold storage, but showed a 75 to 100 percent increase within 1 month after outplanting.

Similarly, seedlings lifted in March showed a 60 percent increase in lipid content 30 days after outplanting.

The general trend was an increase in lipid contents during the 30- and 60-day periods after outplanting. However, the lipid contents of the March-lifted seedlings were lower than those of the January or February seedlings. The data suggest that a buildup of lipids occurs in late fall, but these are rapidly depleted in cold storage.

The overall lipid contents of the roots were lower than those of the shoots and did not differ greatly by lifting date (table 1). Other than a decrease in contents with cold storage, there was no consistent pattern of changes due to treatment.

Total Sugars

Total sugar contents of shoots dropped in cold storage and tended to increase in the field after outplanting (table 2). The lowest percentage of sugar in freshly lifted seedling shoots was revealed in the March measurement. For this date, sugar content was about 50 percent of that of the other three monthly lifting dates.

Total sugars in the roots lifted in February and March were also much lower than in those lifted in December and January. The general trend was a lower sugar content (about 50 percent less) in root samples than in shoot samples. In both the shoot and root components, the sugar fraction appeared to be somewhat cyclic over time. This would suggest that sugar is rapidly utilized or converted into other metabolic products.

Reducing Sugars

The percentage of reducing sugars per gram of seedling shoot or root dry weight suggests that reducing sugars in both the shoots and roots tended to be lower in December-lifted seedlings stored for 30 to 90 days than in freshly lifted seedlings (table 3). The differences were slight at the later lifting dates. However, slightly greater concentrations of reducing sugars occurred in the shoots than in the roots after 30 to 120 days in the field. This observation is consistent with the fact that reducing sugars are synthesized in the foliage.

Table 2.--Percentage of total sugars in loblolly seedlings after lifting at monthly intervals between December 15, 1979 and March 10, 1980

Date lifted	Days of cold storage	Days after field outplanting 0	30	60	90	120
		% total sugar of dry weight				
		Shoots				
Dec. 15, 1979	0	7.31	11.00	9.94	9.54	6.15
	30	4.72	7.94	6.37	8.40	----
	60	4.56	7.35	8.54	----	----
	90	4.06	6.57	----	----	----
Jan. 8, 1980	0	7.33	7.54	10.41	8.02	----
	30	7.87	9.12	7.44	----	----
	60	5.34	8.90	----	----	----
Feb. 9, 1980	0	6.39	6.71	6.78	----	----
	30	4.25	17.15	----	----	----
Mar. 10, 1980	0	3.72	7.48	----	----	----
		Roots				
Dec. 15, 1979	0	8.43	5.17	4.28	2.44	3.05
	30	4.62	4.82	3.88	4.22	----
	60	3.02	4.48	2.72	----	----
	90	2.58	3.10	----	----	----
Jan. 8, 1980	0	4.58	3.28	2.98	3.90	----
	30	3.41	4.45	2.38	----	----
	60	4.84	3.40	----	----	----
Feb. 9, 1980	0	2.60	4.58	1.76	----	----
	30	3.60	3.82	----	----	----
Mar. 10, 1980	0	2.84	3.72	----	----	----

Survival

Mean survival of seedlings lifted in December and planted within 4 days was 80 percent, whereas after 1, 2, and 3 months of storage, it was 67, 61, and 30 percent, respectively (table 4). In contrast, survival of seedlings lifted in January and outplanted immediately was over 56 percent but was not adversely affected by storage for 30 or 60 days.

Survival of seedlings lifted in February and outplanted was 48 percent, but it dropped to 26 percent after cold storage for 30 days. Survival of seedlings lifted in March was only 38 percent; none of these seedlings were stored.

Table 3.--Percentage of reducing sugars in loblolly seedlings after lifting at monthly intervals between December 15, 1979 and March 10, 1980

Date lifted	Days of cold storage	Days after field outplanting: 0	30	60	90	120
		% reducing sugar of dry weight				
		Shoots				
Dec. 15, 1979	0	3.07	3.59	4.72	4.46	4.55
	30	0.88	3.28	2.28	3.44	----
	60	1.50	2.72	5.00	----	----
	90	0.77	4.16	----	----	----
Jan. 8, 1980	0	1.07	3.46	4.51	3.80	----
	30	3.12	2.84	4.05	----	----
	60	1.38	5.10	----	----	----
Feb. 9, 1980	0	2.56	2.28	3.40	----	----
	30	0.88	2.60	----	----	----
Mar. 10, 1980	0	1.47	4.86	----	----	----
		Roots				
Dec. 15, 1979	0	3.32	2.67	3.18	1.96	1.89
	30	1.86	2.88	2.85	3.11	----
	60	1.86	2.61	2.65	----	----
	90	2.01	2.82	----	----	----
Jan. 8, 1980	0	2.24	2.59	2.89	2.54	----
	30	2.58	2.93	2.72	----	----
	60	2.92	2.58	----	----	----
Feb. 9, 1980	0	3.58	1.86	2.87	----	----
	30	3.38	3.20	----	----	----
Mar. 10, 1980	0	3.38	3.20	----	----	----

These data clearly show that the capacity of seedlings to survive varies with lifting date and storage treatment. An attempt to correlate these individual biochemical components with survival failed to show any strong positive relationship. High total sugar contents in roots of the seedlings lifted in December concurred with high seedling survival. However, no overall correlations were found between biochemical constituents and survival.

Table 4.--Second-year survival of loblolly seedlings that were lifted on December 15, 1979, and January 8, February 9, and March 10, 1980

Day lifted	Days of cold storage before planting			
	0	30	60	90
	% survival			
Dec. 15, 1979	79.8 ± 1.66	67.2 ± 0.29	60.8 ± 8.84	30.5 ± 5.26
Jan. 8, 1980	55.8 ± 0.29	56.3 ± 1.77	57.5 ±14.82	----------
Feb. 9, 1980	47.5 ± 4.24	25.5 ±12.37	----------	----------
Mar. 10, 1980	37.5 ±13.40	----------	----------	----------

DISCUSSION

Survival in this study was probably influenced more by weather following outplanting than by any other factor. Monthly rainfall data show that the summer of 1980 was extremely dry for the 5-month period from May through September. Rainfall for the period was 5 inches, compared to the 30-year average of 21 inches. This drought was more severe in central Louisiana than any drought in the previous 30 years, resulting in high mortality among many first year plantations.

Early planting is successful if seedlings are sufficiently cold hardy. Seedlings lifted in mid-December and stored for 2 months before planting had a higher survival percentage than freshly lifted (February) seedlings. Likewise, seedlings lifted in January and cold-stored for 1 and 2 months had higher survival percentages than seedlings freshly lifted in February and March. The survival-storage interaction indicates that some type of survival enhancement factor is present in seedlings lifted at certain times and that this factor is somewhat immune to degradation during cold storage. The survival for the December seedlings that were planted without storage indicates the maximum expected. Although survival did drop for seedlings cold-stored 1 and 2 months and for all of the January-lifted seedlings, the seedlings from the December and January liftings had higher survival when planted after cold storage than when lifted and planted after the same lengths of time in the nursery.

The survival data clearly show that there is a "lifting window" during the harvesting season and that lifting during this period increases survival. Seedlings lifted during this optimum period also store well. This suggests that overall field survival would be improved if it were possible to harvest and store more of the crop during this lifting window, which will likely vary from year to year. Therefore, more research will be required to determine how this window can be predicted.

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