KRAFT-POLYETHYLENE BAGS RECOMMENDED FOR PACKING AND STORING LOBLOLLY SEEDLINGS

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Reported here are studies made in north Mississippi during 1960 and 1961 to test the field performance of loblolly seedlings packed and stored in kraft-polyethylene (K-P) bags.[1] Such bags have been used to store west coast conifers up to 6 months[2,3], while in England conifers have been stored in polyethylene film for long periods.[4]

1960 Study

Methods. --K-P bags were compared to standard Forest Service bales in a factorial arrangement of these variables:

Time of lifting: December 11, 1959, January 4, 1960, and February 2, 1960.

Storage method: On racks in a cold-storage room held at 33° to 38° F., and in a warehouse where temperatures were kept above freezing but ranged up to 80°.

Storage duration: 1, 5, and 9 weeks.

The 36 treatments were replicated four times, in randomized blocks. Fifty seedlings were planted at 2- by 3-foot spacing in each of the 144 plots, a total of 7,200 trees. Comparisons among treatments were in terms of first-year survival and growth.

Seedlings assigned to the K-P bags were prepared in bundles of 50; the root end of each bundle was packed with moss and wrapped in butcher paper. Each bag was packed with **six** bundles placed alternately tops to roots. Then the bag was closed by wrapping the open end around the body and fastening it with two pieces of twine or two metal straps. Eighteen bags were prepared in this way. Eighteen Forest Service bales of 300 seedlings each were required for the test; they were packed according to standard nursery procedure.

Bales stored in the warehouse were watered at 2- to 3-day intervals. Those to be kept in cold storage were watered on arrival but not afterward. The K_P bags were not watered.

Results. --Seedlings from the bales and the bags survived and grew equally well. Survival for both methods averaged 78 percent, growth 0.5 feet.

1 The double-wall kraft-polyethylene bags have an 11.5-inch gusset, 24-inch face width, and 30-inch face height. Polyethylene (or unithene), which is waterproof but permeable to gases, is applied as a 10-pound laminate to the inner-facing wall of 50-pound kraft. The other wall is 50-pound wet-strength kraft. The bottom is sewed. K-P bags are manufactured in various sizes by several large paper companies. Recent bids to the Forest Service averaged under $200 per thousand bags. The bags for the studies reported here were furnished by the Portco Paper Company, Vancouver, Wash., and the Union Bag-Camp Paper Corporation, New York, N.Y.

2 Aldhous, J. R. Nursery plants in polythene. Quart. Jour. Forestry 54: 28-32. 1960.

3 Duffield, J, W., and Eide, R. P. Polyethylene bag packaging of conifer planting stock in the Pacific Northwest. Jour. Forestry 57:578-579. 1959.

4 Lanquist, K. B., and Doll, J. H. Effect of polyethylene and regular packing methods on ponderosa pine and Douglas-fir seedlings stored over winter. U.S. Forest Serv. Tree Planters' Notes 42, pp. 29-30. 1960.

Survival averaged 82 percent for seedlings from cold storage and 74 percent for those held in the warehouse (table 1); these differences were significant at the 1-percent level. Cold-stored trees grew 0.52 foot, those from the warehouse 0.50 foot; though small, these differences were significant at the 5-percent level.

Storage for 5 and 9 weeks had a detrimental effect on seedlings lifted in December (table 2). Those lifted in January, however, performedbest after being stored for 9 weeks, and the performance of seedlings lifted in February improved directly with length of storage. Month of lifting and duration of storage were confounded by weather conditions after planting. After the December planting the weather was mild for a month. The January and February plantings were followed by periods of cold, including lows of 15° F. Temperatures after the February 11 planting were particularly severe, with subfreezing lows for 25 out of the first 33 days.

1961 Studies

Methods.--Three studies were installed in 1961 (table 3). The first compared alternate methods of packing seedlings in K-P bags. The second and third further evaluated the effects of packing methods and storage duration on the condition of seedlings as measured by their ability to tolerate root exposure.

The first 1961 study compared the field performance of seedlings that were packaged in K-P bags with their roots: 1. packed with moss, 2. packed without moss, or 3. sprayed with Rutex, a hydrophilic agent. 5 To help maintain humidity, about 1 pound of saturated moss was placed in a corner of each bag in treatments 2 and 3.

Six bags of 300 seedlings were packed according to each of the three methods. Seedlings were oriented and bulk-packed (in contrast to the 50-tree bundles used in 1960) as in Forest Service bales. The open tops were sealed with tape and stapled prior to tying.

TABLE 1.--First-year survival of loblolly seedlings packed in Forest Service bales and kraft-polyethylene bags--1960 study

Type and duration of storage (weeks)	Storage method		Means
	Bales	K-P bags	
Cold storage:	*Percent*	*Percent*	*Percent*
1	88	82	85
5	83	81	82
9	77	81	79
Means	83	82	82
Warehouse storage:			
1	84	87	85
5	67	73	70
9	70	66	68
Means	73	75	74

TABLE 2.--First-year survival and growth of loblolly pines lifted in December, January, or February and planted after 1, 5, or 9 weeks of storage--1960 study. Data are averages for bale- and bag-packed seedlings in cold and warehouse storage

Storage duration (weeks)	Lifted December 1959	Lifted January 1960	Lifted February 1960	Means
	SURVIVAL			
	Percent	*Percent*	*Percent*	*Percent*
1.....	[1] 93	[2] 85	[3] 78	85
5.....	[2] 74	[3] 66	[4] 88	76
9.....	[3] 37	[4] 92	[5] 91	73
Means.....	68	81	86	78
	HEIGHT GROWTH			
	Feet	*Feet*	*Feet*	*Feet*
1.....	0.6	0.5	0.4	0.5
5.....	.4	.4	.5	.5
9.....	.3	.6	.6	.5
Means.....	.5	.5	.5	.5

Planting dates:
[1] December 17, 1959.
[2] January 14, 1960.
[3] February 11, 1960.
[4] March 14, 1960.
[5] April 7, 1960.

In the Rutex application, single layers of seedlings were spread out on a board, the stems covered, and the roots sprayed from above and below with a paint gun having a nozzle pressure of 30 p.s.i. Rate of application was 5 pints per 1,000 trees.

All seedlings were lifted on February 1, 1961. Comparisons included cold and warehouse storage for 1, 5, and 9 weeks. A total of 3,600 trees were planted--50 in each, of 18 treatment plots replicated four times.

The second study compared the tolerance to root exposure of seedlings from the nine treatment combinations held in warehouse storage. Seedlings were laid flat with the roots suspended about 3 inches above the soil surface, exposed to full sunlight for 20, 60, and 120 minutes, and then planted. Drying conditions were almost identical on the three planting dates. Planting was in three randomized blocks on the same days as in the first study. The 27-treatment plots in each block consisted of a single, row of 10 seedlings, a total of 810 seedlings.

The third study tested a lighter application of Rutex and a greater range of exposures after cold storage for 1 and 5 weeks. Roots of seedlings lifted on February 28 were sprayed with Rutex at a pressure of 100 p.s.i; and an average rate of 14 ounces per 1,000 seedlings. Many seedlings in this study had flushed in the nursery: Some had new shoots 3 inches long. Two K-P bags were packed with 1,000 sprayed seedlings, and two with 1,000 unsprayed seedlings in moss.

Roots were exposed for 0, 15, 30, 60, 120, and 240 minutes on the same days as the last two installations of the two previous studies. Twenty-five seedlings were planted in each of 24 treatment plots, each replicated three times in a randomized block design, a total of 1,800 trees.

Results. --Survival and growth in the first 1961 study were best (98 percent and 1.4 feet) for seedlings packed with moss; but almost as good (95 percent and 1.3 feet) for those packed without moss (table 3). The heavy application of Rutex was definitely detrimental, though survival averaged 90 percent and growth 1.1 feet. Method or duration of storage did not affect survival of seedlings packed with moss, but survival of seedlings packed without moss was reduced slightly (to 96 percent) by cold storage for 9 weeks, and somewhat more (to 91 and 90 percent) by warehouse storage of 5 and 9 weeks. Packing with or without moss had little effect on growth. Seedlings from cold storage, either with or without moss, outgrew those held in the warehouse, the difference of 0.1 foot being significant at the 1-percent level. Growth declined with length of storage, perhaps because storage shortened growing seasons.

Results of the second 1961 study were generally consistent with those of the first, and indicated that prolonged warehouse storage without moss, either with or without Rutex, increased susceptibility to exposure damage (fig. 1). Desiccation during storage was probably responsible, for after 9 weeks' storage the stems and roots of seedlings packed without moss contained significantly less moisture than those of seedlings packed with moss. Rutex did not reduce desiccation.

In the third study, nondormant seedlings that had been given the light application of Rutex and packed without moss performed similarly to unsprayed seedlings packed in moss. When planted promptly, seedlings in cold storage for 5 weeks survived as well, and grew nearly as well, as those stored 1 week. Exposures before planting reduced survival and growth of those stored 5 weeks significantly more than of those stored 1 week (fig. 2).

TABLE 3.--Method of packing in K-P bags, type of storage, and storage duration as influences on first-year performance of loblolly seedlings--1961 study

Packing Methods	SURVIVAL								Means
	Cold storage				Rack storage				
	1 week	5 weeks	9 weeks	Means	1 week	5 weeks	9 weeks	Means	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
With moss.....	98	98	98	98	98	98	98	98	98
Without moss....	98	98	96	98	98	91	90	93	95
Means.....	98	98	97	98	98	94	94	95	97
Rutex.....	92	96	83	90	84	52	28	54	72
	HEIGHT GROWTH								
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
With moss.....	1.6	1.4	1.3	1.4	1.4	1.4	1.2	1.3	1.4
Without moss....	1.4	1.4	1.3	1.4	1.4	1.3	1.1	1.3	1.3
Means.....	1.5	1.4	1.3	1.4	1.4	1.4	1.1	1.3	1.4
Rutex.....	1.4	1.2	.8	1.1	1.1	.9	.7	1.0	1.1

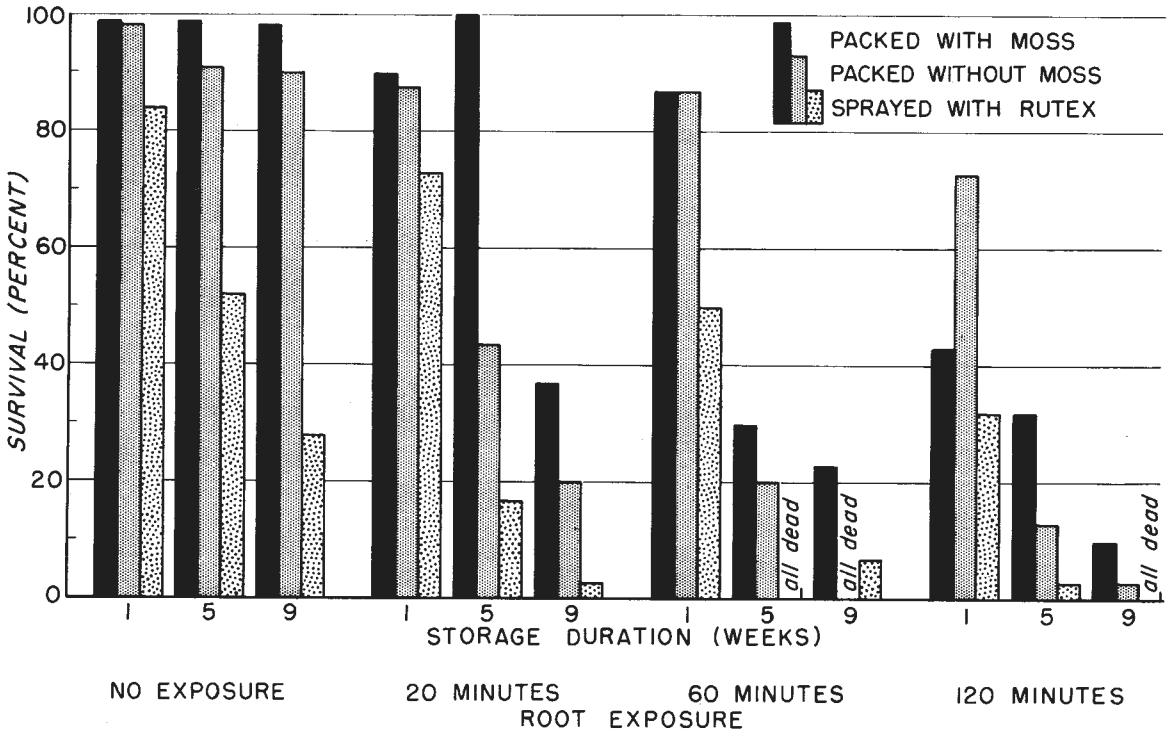

Figure 1.--How length of warehouse storage and method of packing K-P bags affected seedling tolerance to root exposure.

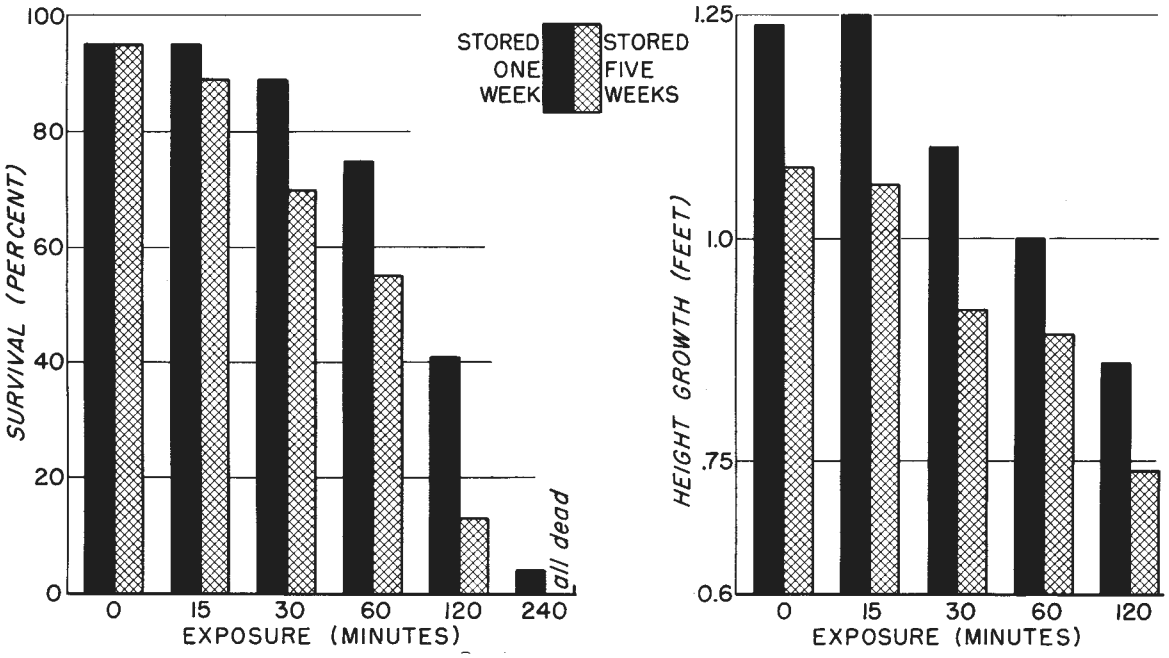

Figure 2.--How root exposure affected seedlings coldstored in K-P bags. Values are averages for seedlings with and without Rutex.

Summary and Recommendations

Kraft-polyethylene bags proved highly satisfactory for packing and storing loblolly pine seedlings in, studies over a 2-year period in north Mississippi. Bag-packed seedlings performed as well as those packed in standard Forest Service bales.

Packing and storage treatments that decreased seedling capacity for survival and growth also reduced tolerance to root exposure during planting. These effects were related to dehydration during storage.

Field performance of seedlings held in cold storage was superior to that of seedlings held in a warehouse.

Heavy applications of Rutex on seedling roots depressed survival and growth and failed to prevent desiccation during storage. Light applications were not detrimental but did not increase seedling tolerance to root exposure.

Seedlings in K-P bags do not require watering or other attention during storage, but certain precautions should be observed. The bags should be kept dry and handled carefully to avoid tears and punctures. They should be protected from freezing and exposure to the sun. Provision should be made to allow air circulation around each bag during shipping and storage. Piling bags one on another without spacers and supports should be avoided. Seedlings stored well in unsealed bags, but sealing or sewing the tops is recommended.

Packing seedling roots with moss as in standard bales is recommended for extended warehouse storage. One bag easily holds 1,000 seedlings packed this way. About 10 pounds of weight per 1,000 seedlings can be saved by packing with only 1 pound of saturated moss, which is an adequate amount for cold storage or at least 1 week of warehouse storage.

A pilot-scale trial with 1 million seedlings on the Yazoo-Little Tallahatchie Flood Prevention Project in 1962 evoked favorable comment regarding convenience of handling and condition of seedlings. Only a few of the bags were torn. The project plans to pack 29 million seedlings in K-P bags in 1963.

Seedlings lifted in December did not store well, regardless of packing method, and planting as early as this in the season has been shown in other studies to expose the trees to unnecessary risks from freezing weather, winter desiccation, and rabbits. These hazards can be minimized by delaying the planting until midwinter, and, if necessary, extending the planting season by storing seedlings lifted before their tops have broken dormancy.