Evaluation of Time-Temperature Monitors for Control of Seedling Storage

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*i - Point time-temperature monitors (TTM) were evaluated for their use as quality indicators for loblolly pine (*Pinus taeda *L.) seedlings. TTM indicators activated at the time of seedling packing accumulate the effects of time and temperature during seedling storage and change color when specified limits are exceeded. TTM indicators have considerable potential as a quality control method for seedling storage. The greatest limitation in their use is the lack of good data on the storage time-temperature relationships for tree seedlings. As nursery workers gain experience with them, TTMs should become important for monitoring seedling quality in storage.*

From the time of packing at the nursery until transplanting in the field, tree seedlings are subjected to a variety of environmental conditions that may ultimately affect their survival and growth.

Normally, seedlings are immediately placed in cold storage (33 to 38 °F) after packing for a 48hour (minimum) cool down period. Later, seedlings are moved from this cold storage unit through the open air and loaded onto a refrigerated truck for transportation to field units. On arrival at the field units, seedlings ,are again moved from refrigerated transport through open air into a second refrigerated storage building. Seedlings remain in this refrigerated building until the day of transplanting. On the day of transplanting, seedlings are removed from refrigeration and may be kept for several hours at outside temperature before finally being transplanted.

During this storage and transportation process, which may last as long as *4* to 6 weeks or more, seedlings may be subjected to a variety of temperatures. Normal cycling of cooling units, variation of temperatures within the units, malfunctions, and improper loading and stacking techniques are some of the reasons for these variations.

To further complicate the problem, the several different people usually involved in the process are unaware, at least in part, of the way the seedlings have been handled.

Recording thermometers are placed about in the centers of cold storage buildings to monitor temperature. These thermometers do not, however, monitor the conditions at the location of each seedling bag. These thermometers do not accumulate storage time of seedlings and are not available in most transport units.

Because of these shortcomings, some type of device is needed to monitor and accumulate data on the treatment of each bag of seedlings and indicate if and when specified limits were exceeded.

Materials and Methods

A time-temperature monitor (TTM) keeps track of the accumulated time and temperature to which a perishable substance is subjected, from the time of harvest until use. The i-Point TTM is an inexpensive monitor designed to integrate time and temperature during storage and transport of any perishable product. The small indicator accumulates all temperature experiences. When a preselected time-temperature limit is exceeded, the TTM will react with an irreversible color change. This color change serves as an early warning system, indicating that some action must be taken to prevent product loss.

Five-thousand i-Point TTM indicators were obtained from i-Point Technologies Ltd. (Washington, DC). Type 2220 was selected for our tests. At 32 °F temperature, the color of this monitor changes at 18, 22, and 28 days. Loblolly pine seedlings in the Ashe Nursery at Brooklyn, MS were lifted in late December 1983 and January 1984 and packaged in K-P bags. As soon as a bag was strapped and tagged (date, seed source, and destination), a TTM was activated and attached to the bag where it could be seen readily during storage. These indicators were checked for color change at specific times during the storage and handling process.

Results

A number of the seedling shipments were received in the field and were outplanted before any color changes were noted on the TTMs. However, several shipments were held until changes to colors 2 and 3 occurred (table 1). Seedlings shipped to Districts A and B were planted soon after the change of the TTM to color 2. In these two shipments the temperatures related well to length of storage. Seedlings shipped to District C took 24 days to change to color 2, indicating that they were stored at lower temperatures, averaging about 30 °F. A check of the records indicated that temperatures were lower than planned.

Seedlings at District D reached color 2 in 12 days. The temperature must have been at about 45 °F for the color to change this early in storage. Records confirmed that the unit was not cooling properly. The results do show that TTM can serve as a quality-control technique for seedling storage. However, because these results were not correlated with field performance, the color changes could not be related to seedling survival.

Table 1—*Color change in loblolly pine seedlings shipped to four ranger districts*

Ranger district	Lifting date	Average days for color change		Integrated storage temperature (°F)[1]
		Color 2	Color 3	
A	12/20/83	14	–	39
B	12/20/83	16	–	41
C	1/12/84	24	–	30
D	1/12/84	12	16	45

[1]Determined from the curve of TTM Type 2220.

Conclusions

Preliminary studies of i-Point TTM indicators show that they have good potential for use in quality control of seedling storage. At this time, however, there is not enough biological information to specify the type of TTM indicator that closely relates storage conditions to field performance. Further research is needed to develop these relationships.

Even without this information, TTMs can be useful in monitoring seedling storage as a means of detecting the effects of cooler failures, lengthy storage, or both. In fact, they will integrate the effects of both of these variables and alert the silviculturist of problem situations that require immediate action.

The psychological effects of the TTM may be one of its greatest values. Because of its presence, personnel are seemingly more aware that seedlings are perishable products and must be cared for properly. This awareness results in closer inspection and greater care of seedlings.