PROBLEMS WITH SEEDLING DORMANCY AND FREEZING

T. A. Dierauf

Abstract

Muriate of Potash and Seedling Dormancy - application of muriate of potash (KCl) containing the equivalent of 100 and 200 pounds per acre of K_2O on September 15 reduced survival of seedlings lifted on November 1, November 15, and December 1 and placed in cold storage for two weeks before planting.

Freezing in Storage - storage of dormant seedlings at 20 degrees Farenheit for one month caused complete mortality in 1972 and 95 percent mortality in 1973. However, in 1978 dormant seedlings that stayed frozen in unheated buildings for approximately two months survived well.

1976-77 Freeze Damage in the Seedbeds - seedlings with tops severely damaged when the soil stayed frozen for about seven weeks survived only about half as well as seedlings that had no top damage.

Key Words: Seedling dormancy, Freeze damage, Muriate of Potash, Storage

The three studies I will talk about this morning are concerned with cold weather. The past two winters in Virginia have been record breakers for cold weather, so cold weather has been on our minds, but even in normal winters, cold weather is a problem in Virginia for at least four reasons:

1. Seedbeds freeze up so seedlings can't be lifted

2. The soil at the planting site freezes so seedlings can't be planted

3. Seedlings stored in barns and open sheds commonly freeze in the packages

4. Once planted, seedlings take a beating when the ground is frozen so the roots cannot take up water.

Ideally, we would like to wait until most of the severe cold weather is over, and plant from about the middle of February through March. But we can't get the job done in this short period of time, so in practice we have to start much earlier, and usually are still planting in May.

MURIATE OF POTASH AND SEEDLING DORMANCY

Introduction

One way to avoid some of the problems of severe, freezing weather would be to start planting in the fall. We normally start planting about December 1, but from the weather standpoint, November would be a good month to plant. In a normal season, the soil seldom freezes in November, and soil moisture is usually adequate. At the 1976 Southeastern Area Nurserymen's Conference, two years ago, I discussed our tests of October and November planting of loblolly pine (Pinus taeda L.) using seedlings that had not yet hardened off or become dormant (Dierauf 1976). You may remember that survival was satisfactory for November 1 and November 15 plantings when the seedlings were planted within a day of lifting. But after storage for two weeks survival was not satisfactory. The ability to withstand storage increases through November, and by December 1 our seedlings are fully dormant and store satisfactorily.

If we could find some way to hasten dormancy, to move up the date when seedlings become fully dormant, we could safely start planting earlier than we do now. We had been hearing for several years about the favorable effect muriate of potash has on hastening dormancy, so in the fall of 1976 we decided to test potash applications in our nursery at New Kent.

Procedure

We talked with Dr. Chuck Davey about what rates of muriate of potash (KCl) to apply and on what dates. Soil tests indicated we already had about 100 pounds per acre of K_2O in the soil, which Chuck said was about normal for nursery soils at this time of year. He suggested rates of muriate of potash that would supply 0, 100, and 200 pounds per acre of K_2O. We also tried two different rates of application, September 15 (the usual date of application) and October 15. This provided six different KCl treatments. Based on our earlier work with fall planting, we planned on three different lifting dates: November 1, November 15 and December 1. This made a total of six KCl treatments x three lifting dates = 18 plots per seedbed block. We installed three seedbed blocks in different parts of the nursery. Each plot was four feet long, so a seedbed block was 72 feet long.

On November 1, when it was time for the first lifting, we could see no differences among the KCl treatments. Foliage color was uniform over all plots. We talked to Chuck about whether we should go ahead with the field planting. We finally decided to lift and plant only the September 15 KCl applications.

The main reason for this decision was that the fall of 1976 was unusually cold in Virginia. Average minimum temperature was 1.3, 4.9, and 6.3 degrees lower than normal in September, October and November respectively. In the latter half of October the temperature fell below freezing on eight days at nearby Byrd Field, and in November the temperature fell below freezing on all but nine days, including four days below 20 degrees. We decided that the October 15 application of KCl probably had had little time to affect dormancy, and so dropped it.

For each of the lifting dates we made an immediate planting, either the same day or the day after lifting, and also placed seedlings in cold storage for two weeks before planting. The planting part of the study was, therefore, similar to the fall planting studies we had been installing for several years.

We wanted to find out whether KCl applications would improve the storability of seedlings lifted in November.

Weather After Planting

I have already mentioned that the average minimum temperature in November was 6.3 degrees below normal. December was also unusually cold in Virginia, and January was the coldest on record. The effect on survival of seedlings planted prior to January was severe.

Results

We tallied survival in the spring of 1978, after the seedlings had been through the second winter in the field. Survival was unsatisfactory, even for seedlings planted within a day of lifting, but the effect of two weeks of storage was similar to what we found in the past (Table 1). In Table 1, KCl treatments have been combined. The interaction between lifting date and storage is significant way beyond the .005 level.

Table 1. Survival percent after one year, KCl treatments combined

Date Lifted	Planted Immediately	Stored 2 Weeks
November 1	53.3	18.9
November 15	45.6	30.0
December 1	45.0	55.0

The application of KCl did not improve the capacity to withstand storage, in fact, the reverse was true: seedlings receiving KCl did not survive as well after two weeks in storage, and seedlings receiving the equivalent of 200 pounds of K_2O did not survive as well as seedlings receiving the equivalent of 100 pounds of K_2O (Table 2). When stored seedlings were analized separately, the effect of KCl was significant at the .01 level.

Table 2. Survival percent after one year, for seedlings stored two weeks

Date	K_2O Applications		
Lifted	0	100	200
November 1	23.3	20.0	13.3
November 15	36.7	28.3	25.0
December 1	61.7	51.7	51.7

Our experience with seedling survival studies is that when first year survival is high, very little additional mortality will occur the second year. But, when first year survival is low, as in this study, we sometimes get considerable additional mortality the second year. It is unlikely, however, that the relationships will change much.

EFFECT OF FREEZING IN STORAGE

Introduction

It is common practice in Virginia for landowners to store seedlings in unheated barns and sheds between the time we deliver the seedlings and the time they are planted. Seedlings commonly freeze in the packages. In 1970 and 1971 we conducted some tests in which fully dormant seedlings, in packages, were allowed to freeze during short periods (two to three days duration) of unusually cold weather when the temperature ranged from the low teens down to zero degrees Farenheit. Survival was not reduced by freezing for such short periods (Garner and Dierauf, 1974). Other people, in earlier tests further south, reported quite different results. Hodges (1961) reported 99 percent mortality of loblolly seedlings after being frozen at 20 degrees Farenheit for 48 hours. Bean (1963) reported complete mortality of loblolly seedlings after being frozen at 18 degrees Farenheit for 36 hours. Byrd (1963) got results more like ours: storing loblolly seedlings at 20 degrees Farenheit, he reported 96 percent survival after 48 hours, but only 50 percent after one week, and two percent after two weeks.

Tests of Frozen Storage

Based on our own encouraging results for short term freezing, and the possibility that loblolly in Virginia might be genetically better adapted to withstand freezing than loblolly further south, we decided to test long term frozen storage of loblolly seedlings, as is successfully done with northern species of pine and spruce. The only facility we had available was a seed storage room maintained at a constant temperature of 20 degrees Farenheit. A temperature in the upper 20's would have been preferred.

Tests were installed in both 1972 and 1973. Seedlings were lifted on March 9 for the 1972 test and February 22 for the 1973 test. Seedlings were graded to remove under-sized seedlings, root dipped in a kaolin clay slurry, and put up in standard 1,000 seedling packages. Six packages were placed in cold storage the same day the seedlings were lifted, and after a week three of the packages were removed from cold storage and placed in the seed storage room at 20 degrees Farenheit. Thus, seedlings were not immediately frozen, but were first placed in a conventional cold storage facility for a week. There were six treatments: planting after one, two and three months of storage, comparing conventional cold storage with frozen storage. The results can be stated briefly. Frozen storage didn't work. In 1972 all of the frozen seedlings died. In 1973, five percent of the seedlings survived after one month of frozen storage, but all seedlings died after two and three months storage.

Inadvertent Long Term Freezing

Based on these tests of frozen storage, we concluded that loblolly pine in Virginia cannot tolerate extended periods of freezing. However, this past winter, 1977-78, was also unusually cold and presented another opportunity to test extended freezing, but this time at temperatures which fluctuated with outdoor temperatures, rather than being maintained at a constant 20 degrees Farenheit. Westvaco and Georgia Pacific each had a large number of seedlings in storage that stayed frozen for most of January and February.

Georgia Pacific received their trees from our New Kent Nursery on December 21 and stored them in a brick building open on one end. Westvaco received their seedlings from the same nursery on January 6 and stored them in a log tobacco barn. The ground stayed frozen and planting was impossible until March. Both companies decided not to plant their seedlings, but gave us some of the seedlings for testing.

We obtained five packages (1,000 seedlings each) from each company and randomly selected one seedling from each of the twenty 50-seedling bundles in each package. This gave us a sample of 100 seedlings from each company. We took a similar 100 seedling sample from some freshly lifted seedlings. These seedlings were planted on March 22, in five blocks of 20 seedling rows. Much to our surprise, these seedlings survived very well. On July 19, half way through the first summer, all of the Georgia Pacific seedlings, 98 of the check seedlings, and 97 of the Westvaco seedlings were alive, and most of them were growing vigorously.

Discussion

These tests of the effect of extended periods of freezing raise some puzzling questions. Is there a difference between extended storage at artificially maintained constant temperatures and naturally fluctuating temperatures? In the 1972 and 1973 tests at a constant temperature of 20 degrees, mortality was almost complete after one month of storage. In the 1978 test, after two months of storage at fluctuating temperatures that were cold enough that the seedlings stayed frozen, practically all seedlings survived. Or are the differences in results due to seedling differences? Are some seedling crops, from the same nursery, better able to withstand freezing than others? In all tests, seedlings were lifted well after the time when they become fully dormant, so dormancy should not have been a factor, unless there are differences in the degree of dormancy from year to year.

1976-77 WINTER DAMAGE IN THE SEEDBEDS

I have already mentioned the unusually cold weather we had in Virginia during the fall and winter of 1976-77. January was especially severe. The ground froze to record depths in many parts of Virginia. At our New Kent Nursery there was a period of seven weeks when seedlings could not be lifted because of frozen ground. At our Augusta Nursery the frozen period was even longer. Browning of loblolly seedling tops began in January and became progressively worse through February and into March, when it finally stabilized. The damage was so bad at Augusta that we decided to plow under the entire loblolly crop. At New Kent the damage was much less severe and we went ahead and sold the seedlings. We reported on the extent of damage to loblolly seedlings at New Kent (Dierauf and Olinger, 1977). We concluded that the damage was caused primarily by desiccation rather than outright cold damage.

We planted 100 each undamaged, moderately damaged, (less than one-third of top killed), and severely damaged (more than one-third of top killed) seedlings on March 2. The seedlings were lifted from 50 different locations, taking two seedlings of each damage class at each nursery location.

Survival was tallied this past spring, after the seedlings had been through the second winter (Table 3).

Survival was not good even for the undamaged seedlings, but the severely damaged seedlings survived less than half as well. The spring and summer of 1977 were dry. Between the winter cold and the spring and summer droughts, the 1976-77 season was the worst for seedling survival we have had in Virginia in a long time. Had the growing season been more favorable, the damaged seedlings might have fared better.

Table 3. Survival percent after one year

No Damage	66
Moderate Damage	58
Severe Damage	32

LITERATURE CITED

Bean, S. D. 1963. Can Bundled Seedlings Survive Freezing? Tree Planters Notes. No. 58.

Byrd, Roger R. 1963. Freezing Temperatures Affect Survival of Planted Loblolly and Slash Pine Seedlings. Tree Planters Notes. No. 58.

Dierauf, T. A. 1976. Proceedings, 1976 Southeastern Area Nurserymen's Conference. p. 30-36.

Dierauf, T. A. and H. L. Olinger. 1977. January 1977 Cold Damage to Loblolly Seedlings at New Kent Nursery. Virginia Division of Forestry Occasional Report. No. 51.

Garner, J. W. and T. A. Dierauf. 1974. Effect of Freezing on Survival of Loblolly Pine Seedlings. Virginia Division of Forestry Occasional Report. No. 44.

Hodges, Charles S. 1961. Freezing Lowers Survival of Three Species of Southern Pines. Tree Planters Notes. No. 47.