

Ponderosa Pine Planting Stock

studies indicate that time of lifting and length of storage before replanting influence survival of ponderosa seedlings

Edward C. Stone and Gilbert H. Schubert

Cold storage of ponderosa pine seedlings—between nursery and field—is an integral part of the planting program in California. However, forestry agencies have been concerned for a number of years with the effect of storage on the subsequent survival of pine seedlings transplanted to the field.

Until recently all ponderosa pine seedlings planted in California were raised at either of two Forest Service nurseries. At the Mt. Shasta Nursery, near McCloud, some seedlings have been dug each fall and placed in cold storage for early spring planting on the warmer low elevation sites. The remaining seedlings have been dug later in the spring. Further south at the Oakdale Nursery, where seedlings often begin top growth a month or more before planting sites are free of snow, all of the seedlings have been dug in early February and held in cold storage or heeled-in on the planting site until needed. Thus some stock from the Mt. Shasta Nursery has been stored 5–7 months and some has been freshly lifted, while all Oakdale stock has been stored or heeled-in 1–3 months.

Survival of seedlings from the Oakdale Nursery has generally been good; survival of seedlings from the Mt. Shasta Nursery has been variable, with failures almost as common as successes. Field investigations have not furnished an answer but did suggest that seedling deaths often occur before soil moisture is limiting and—under certain conditions—high survival is possible.

As the first step, in an effort to evaluate the effect of cold storage on seedling survival, a study of the physiological condition of the seedling—as expressed by root development subsequent to transplanting—was undertaken.

In brief the study consisted of digging seedlings from the nursery every 15 days, replanting them in the greenhouse after 0, 1, 2 and 3 months of cold storage, and redigging them 30 days later and recording any new root growth.

Two-year-old ponderosa pine seedlings grown at the Mt. Shasta Nursery were used in the study.

Seedlings were dug on the 15th of September, 1st and 15th days of October and November, and the 1st of December, packed in shingle-tow, and shipped by freight to Berkeley. In Berkeley, 60 seed-

lings were repacked—10 per can—with their roots in moist vermiculite. Each of the cans was in turn sealed in a plastic bag and placed on a shelf in a 34°F cold storage room. Immediately upon receipt of the seedlings, and after 1, 2, and 3 months of cold storage, 20 seedlings were planted—10 per galvanized container—in sandy loam. They were then watered, drained, and placed in a 68°F water bath in the greenhouse; two weeks later they were again watered. One month later the galvanized containers were lifted from the water bath and the soil carefully washed from the roots of the seedlings.

Seedlings whose needles had turned completely brown and whose stems had dried and shriveled during their month stay in the greenhouse were judged dead. The root systems of the remaining live

seedlings were examined. The new roots which had just started to harden, but could be recognized as new roots, were counted and those 0.5" and longer were measured.

The air temperature in the greenhouse did not fall below 68°F at night and with but few exceptions did not exceed 95°F in the daytime. Thus the seedling roots were exposed to a constant temperature, an abundant supply of moisture and nutrients, and the top was exposed to a varying air temperature and a changing photoperiod.

Before any seedlings were replanted in the greenhouse their roots were pruned to about 6", and any white root tips still present pinched off.

Seedling survival after storage improved after each two-week delay in lifting—until November 1. Thereafter there was no significant improvement.

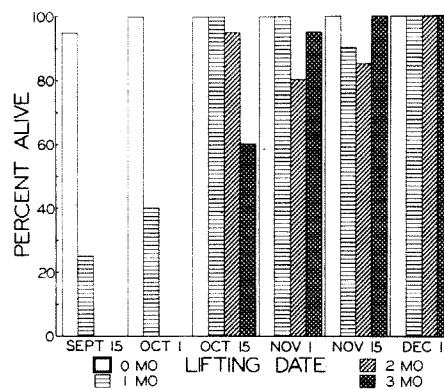
Each month of added storage significantly reduced survival. However, the reduction was most evident when the stock had been lifted before October 15. None of the stock lifted on September 15 and October 1 survived three-month storage. In contrast, 60% survived when lifting was delayed until October 15, and 95% when lifting was delayed until November 1.

When seedlings were lifted before November 1, the number of lateral roots that elongated following storage was significantly reduced by each month of additional storage. When lifted after November 1, the effect was not the same. One and two months of storage clearly reduced the number of lateral roots that subsequently elongated, but an additional month of storage appeared to increase the number although statistical significance could not be established.

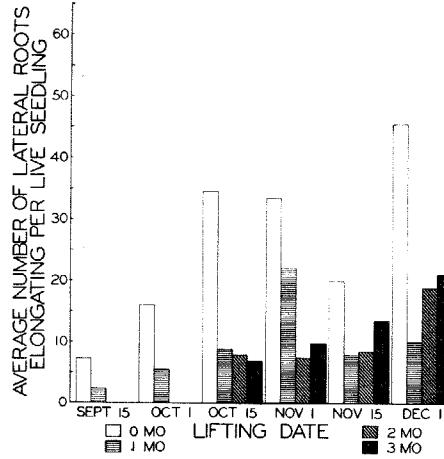
The results of these studies strongly suggest that the date seedlings are lifted for cold storage is responsible, in part at least, for the variable success experienced when Mt. Shasta and Oakdale stock are planted out in the field.

Until recently, a large amount of the Mt. Shasta stock was lifted and placed in storage during early October, and Oakdale stock during February. Although the experimental data cover only the September to December period, they indicate that the deleterious effect of stor-

Survival of ponderosa pine seedlings after one month in the greenhouse following cold storage.



Lateral root elongation of ponderosa pine seedlings after one month in the greenhouse following cold storage.



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Ammonium Bicarbonate Toxicity

root injury occurred from within few hours to several weeks in solution culture tests with citrus, avocado, and soybeans

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The ammonium source of nitrogen is often considered less desirable than other nitrogen sources for some plants. Nitrate is believed—by many people—to be superior to ammonium nitrogen for citrus, especially under acid soil conditions.

Workers in Florida showed recently that poor growth in citrus with ammonium nitrogen could largely be overcome by raising the pH—relative acidity—alkalinity—of the nutrient medium to about 6.

It was reasoned that if ammonium nitrogen were less toxic at pH 6 than at pH 4 it might be even less toxic if bicarbonate were present and if the pH were above 7. The hypothesis involved the fixation of the bicarbonate into organic acids which in turn would be combined with the ammonia to form amino acids and thus provide a means of rendering ammonia nontoxic. The treatment, however, proved to be almost lethal to the plants.

Root Injury

Avocado roots were severely injured in solution culture by ammonium bicarbonate within 72 hours and by urea with bicarbonate in about seven days. They were visibly injured by ammonium sulfate in the presence of calcium carbonate, also in solution culture, in about two weeks. Actually avocado roots were injured somewhat by bicarbonate in the

presence of nitrate. Such injury occurred in about three weeks.

Roots of citrus and soybean seedlings were injured much in the same manner as were avocado roots, but the injury did not occur quite so rapidly, nor was there injury with a combination of bicarbonate and nitrate.

Bicarbonate concentrations of 5 m.e.—milliequivalents—per liter or less produced relatively little toxicity while those 10 and above produced considerable toxicity. Likewise the lower ammonium concentration, the less the toxicity.

Dry Weights of Roots of Soybeans	
Treatment	Wt. in grams
ammonium-N pH 4	1.5
ammonium-N pH 6	1.7
ammonium-N pH 7	3.5
ammonium-N-bicarbonate pH 8.5	1.1
nitrate N—pH 4	4.0
nitrate N—pH 6	3.9
nitrate N—pH 7	3.5
nitrate N—bicarbonate pH 8.5	4.0

Control plants in which nitrate or ammonium nitrogen was maintained and in which changes were made often enough to keep microbial activity at a minimum indicated that the combination of ammonia and bicarbonate was necessary to produce the toxicity. Neither alone caused it.

A number of plants were grown in nutrient solutions with ammonium hydroxide to determine if the ammonium

bicarbonate effect could be the result of the hydroxyl ion. Results were inconclusive.

Since a large portion of the nitrogen fertilizer used in California is ammonic, it is of considerable importance to ascertain if these effects obtain in the field, particularly on alkaline or calcareous soils where bicarbonates are always present. Preliminary results with soil tests indicate that there could be some problem, especially since a toxic effect can be pronounced in avocado within hours.

When ammonium nitrogen is applied to neutral, alkaline, or calcareous soils, nitrifying bacteria convert it to nitrate nitrogen. This process is rapid and essentially complete in a few days. It is a safety mechanism that could prevent ammonium bicarbonate toxicity. If soil has been fumigated or sterilized, however, nitrification may be very slow and ammonia application to soils containing bicarbonates may be injurious for some crops.

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age may be closely associated with a failure to achieve physiological hardening or readiness before being placed in storage. If this be true, some of the fall-stored Mt. Shasta stock, in contrast to the Oakdale stock, would have been in a poor physiological condition—perhaps even close to death—when delivered to the planting site the following spring.

Since the weather varies from one year to the next, there is a good chance that the physiological condition of the seedling at a specified date will not be the same each year. Although stock lifted on October 15 did not store well—as

measured by lateral root growth—while stock lifted on November 1 did, October 15 and November 1 are not necessarily critical dates. Weather conditions might be such that stock lifted on October 15 would be physiologically hardened and would store well. Similarly the seed collection zone might be correlated with survival and lateral root elongation one year but not the next. Certainly critical dates can be expected to differ at each of the widely separated forest nurseries in the state.

The physiological condition of a seedling can not be determined by inspection. Stock lifted on October 1 appears the same after storage as stock lifted in November or December; the needles are as

green and the roots as turgid and as firm. However, some rapid method of measuring the physiological activity—perhaps gas exchange or reserve food measurements—may provide the answer.

Although these studies indicate that early fall lifting and storage may produce seedlings that are certain to die, they also indicate that seedling stock lifted and stored later in the year has a good chance of survival.

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