



## Seedling Mortality: Cause & Effect – Dec 2021 to March 2022

### Editor's Note:

*Dr. Tom Starkey wrote the following article. Dr. Starkey is a Nursery and Regeneration Consultant who has worked with ArborGen and other seedling companies in the south for more than 15 years. He began this type of consulting in 2006 while working for the Southern Forest Nursery Cooperative at Auburn University and has continued since retiring in 2016. When seedling issues arise after planting, Dr. Starkey provides an independent evaluation of possible causes for seedling mortality. His conclusions are based upon his examination of seedlings from the planting site, including nursery and planting site data and weather data from the nursery before the seedlings were lifted and the planting site after out-planting.*

In this article, I will share the causes of mortality for seedlings I evaluated that have been planted since December 2021. This report represents seedling evaluations from multiple seedling companies and nurseries.

Seldom is there one causal agent responsible for 100% of seedling mortality. Most commonly, there are 2-3 issues that I feel have contributed to the mortality. Sometimes it is possible to pinpoint where and when the problem occurred; other times, it is not. The most common causes of seedling mortality are

- *seedling planting issues* such as shallow planting, root deformation, root pruning, time of harvest and planting, and seedling storage,
- *planting site issues* such as soil texture, degree and timing of site preparation, and herbaceous weed competition,
- *weather issues* such as freeze events and or heavy rainfall,
- *nursery issues* such as wet soils, time of lifting, length of storage, and improper root culture.

During this past planting season (December 2021 to March 2022), I have observed freeze injury in the cambium of stems and roots, freeze injury to buds and upper stems, symptoms related to wet soils, root deformation and other planting-related issues, insect feeding, lesions associated with seedling lifting at the nursery, and tap roots that were cut too short in the nursery. The reported frequencies below are based on my evaluations of close to 400 seedlings from multiple seedling companies.

### Seedling Planting Issues

Root deformation at the time of planting was found on 22% of the seedlings. Root deformation is not always a problem if the seedlings are planted deep on proper sites. However, in all these cases, the planting hole was not deep enough, and thus planting would be considered too shallow for good seedling establishment. Most of the observed root deformations fell into the "L" or "J" rooted category. This year there were very few "U" rooted seedlings.

In recent years, I have begun to monitor the number of seedlings with root deformation and a broken tap root where the root bends. This year 38% of the seedlings with root deformation also had a broken tap root. This broken tap root occurs when the seedling is pushed into a planting hole that is too shallow. A broken tap root will generally slow up seedling establishment until the root at the break calluses over and begin to grow again.



Photo of root deformation.

Another problem generally associated with too shallow of a planting hole is a portion of the lateral roots, at the top of the root system, found out of the planting hole.

This symptom can slow seedling establishment since white root growth commonly starts on the lateral roots at the top of the root system.



Photo of root deformation.

### Wet Soils Issues

Wet soils can occur in both the nursery and planting sites. When these occur in the winter, when the seedlings are not actively growing and transpiring, injury and death to the fine and fibrous lateral roots and tap root tissue can occur. Although the total amount of rainfall is an important factor, the frequency of rainfall events over a short period of time is of major concern, whether it be in the nursery or on the planting site.

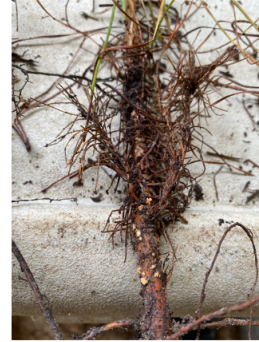
Frequent rainfall events over a short period of time keep the soil profile, especially in the lower portion of the tap root, too wet for fine lateral and fibrous roots. The result is seen in seedlings with numerous small and fibrous lateral roots in the upper part of the root system but much fewer to no lateral roots on the lower part of the tap root.



Roots near soil surface with few lower on root system.



Wet soil: sloughing roots



Wet soil: lenticels

The wet soil symptoms observed this past year were seedlings with lenticels (an indication of anaerobic soils), fine and fibrous roots at the top of the root system, few to no roots further down, dead lower tap root tissue, and sloughing of lateral roots.

Wet soil type symptoms were found in 55% of all the individual cases I examined. The wet soils occurred in the nursery, in the field, or in both locations. Lenticels could be found on most all seedlings identified as coming from wet soils. Approximately 11% of the seedlings with wet soil symptoms had fine fibrous roots at the top of the root system and few to no roots lower. Over 35% of the seedlings with wet soil symptoms had all or a portion of the tap root tissue dead. Sloughing of lateral root tissue was observed in 14% of the seedlings from wet soils. This sloughing of lateral roots only occurred in two cases I examined, but nearly every seedling had sloughing roots.

### Other Minor Issues

Other minor issues observed this year include Pales weevil-like feeding on the stem, lesions on the stem just above the root collar that I attributed to damage during lifting in the nursery, and tap roots that were less than 2" long. Similar short roots have been observed in the past and may be caused by either root pruning by tree planters or improper undercutting in the nursery. I believe these short roots this year occurred in the nursery.



Insect feeding



Short tap root

All these minor issues occurred on just a handful of seedlings and were preventable but not in significant numbers.

### Freeze Injury Issues

The freeze events this year caused a significant part of the seedling mortality observed. Although we observe freeze injury every year, seldom does it kill a seedling unless the freeze event is especially low, as was in 2018 when temperatures fell to 0F to 5F. In most years, freeze injury is seen as a khaki-colored streak up one side of the upper root and stem cambial tissue area. Unless there are significant other confounding issues (such as wet soils or planting issues), freeze injury will normally only set back the normal expected first-year growth of the seedling. Once new tissue in the cambium area is laid down over the freeze injury, the seedling is considered to have recovered.

Temperatures cold enough to cause freeze injury may occur any time from November to April. When a freeze event occurs in November, damage to seedlings in the nursery can occur. However, the long-term impact of these November freeze events is generally minimal since the seedlings are able to remain in the nursery bed and start the recovery process before lifting. However, a spring freeze event, as happened this year, can spell disaster, especially for late-planted seedlings.

We know that as chill hours accumulate beginning in fall and winter, the tolerance (acclimation) of seedlings to freeze events also increases. However, this year we suffered two significant de-acclimation periods.



Freeze injury



These de-acclimation periods eliminated any accumulated chill hours making the seedlings more vulnerable to freeze events. The first was in December, and the second just before a large number of seedlings were planted this year, in February.

Between December 2021 and February 2022, there were several freeze events that most likely caused some freeze injury. Most of these events were isolated and random. However, on March 12/13, 2022, a significant freeze event occurred throughout much of the southern region. Although the temperatures were not extreme, ranging from 18F to 25F, what made the freeze event so significant was that it happened when all the seedlings planted this year had started the



Healthy tissue and freeze injury

active growth process. Multiple types of freeze injury were observed on seedlings.

The typical type of cambial freeze injury on the stem and extending down to the upper root system was observed. This year, however, a large number of buds and the tops of many seedlings were also killed due to the March freeze. On many of these seedlings, buds near the ground line were trying to break and grow.

This spring freeze caused so much mortality because it affected the ability of the seedlings to grow new roots. In the spring, new root growth depends on current photosynthesis (not stored carbohydrates). The death of the buds and upper stem this year reduced new root growth by reducing current photosynthesis and the seedling's ability to transport carbohydrates to the root system.

At least 29% of the seedlings I evaluated had typical root and cambium area freeze injury. I am sure this number is higher as many of the samples I observed had not fully developed the cambium-type symptom. Some of the seedlings were collected a full four weeks after the March 13 freeze, but the freeze injury was just starting to be visible.

Over 64% of the seedlings I considered to have freeze injury (based upon the presence of cambial injury) had numerous dead buds and dead upper stems. Of this number, 95% were planted after February 15.

### Mortality issues occurring together

As mentioned above, seldom does only one factor contribute to the overall mortality of the seedlings. This year the two most frequently observed mortality issues occurring on a planting site together were freeze injury and wet soil type symptoms. These are two difficult factors to overcome since both impact root growth.

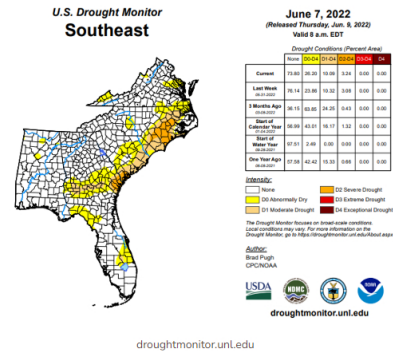
### What the seedlings are facing the rest of this year:

Seedlings can frequently recover from many of the problems discussed above if the site conditions and weather following the event are favorable. Probably the most critical factor for seedling recovery is the amount of soil moisture.

Extremes in rainfall are not favorable. Roots need moisture, but too little or too much will hurt seedling growth and recovery.

Many areas in the southern planting area have recently experienced drought conditions, with the coastal areas of the south forecasted to continue in a drought.

For seedlings that have experienced both the March 13 freeze and problems with wet soils (especially late-planted seedlings), this prediction is not encouraging.



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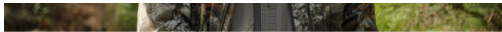
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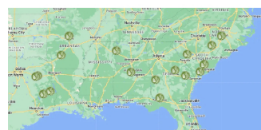
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