

# Physiology of Pine Seedlings Affected by Excessive Rainfall Prior to Lifting

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**Abstract**—Observations over the past two decades indicate that waterlogged conditions in the nursery can adversely affect the transplantability of loblolly pine (*Pinus taeda*) seedlings. Waterlogged seedbeds can occur when frequent rain falls over an extended period of time. Anaerobic conditions can result when warm soils remain saturated for just a few days. At some nurseries, rainfall exceeded 50 mm/week for a period of three weeks or more during November. Fertilization in October might exacerbate the problem due to an increase in respiration of soil microbes. An extended period of anaerobic conditions can alter both the physiology and structure of pine roots. When seedlings are lifted just after a period of anaerobic soil and transplanted in December or early January, a quick death can result due to a lack of new root growth (death often occurs from the roots up as opposed to from the tops down).

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Over the last several years, the Auburn University Southern Forest Nursery Management Cooperative has inspected several plantation failures that were not caused by poor planting practices. Failures in Alabama and Georgia appeared to be related to reduced seedling physiology since no pest related symptoms were detected and morphology was acceptable (root mass was adequate and shoot length was not excessive). Symptoms included blackened root surfaces, over development of lenticiles, no new root growth, rapid mortality, and seedlings dying from the roots up. Root systems deteriorated quickly when seedlings were stored under refrigerated conditions for three weeks or less. These symptoms were similar to those described by Oak (1983) for seedlings outplanted in South Carolina.

A common factor for these seedlings was unusually high rainfall during the month prior to lifting (e.g. November). Typically, more than normal rainfall occurred over a three or four- week period and as a result, the soil remained “waterlogged” for an extended length of time. The resulting anaerobic soil conditions would have a negative impact on root physiology. In some cases, lenticiles were observed on stems and roots. In addition, aerenchyma can form in the roots (McKevlin et al. 1987). Under laboratory conditions, aerenchyma can develop in just 15 days (Topa and McLeod 1986). Waterlogged soils not only affects root anatomy, but low soil oxygen reduces the rate of nutrient uptake (Gadgil 1972) and lowers the transport of photosynthate to the roots (Kozłowski 1984).

At many locations in the South, average rainfall for the month of November is less than 25 mm per week. In some years, November rainfall exceeds twice this amount and subsequent survival after transplanting is sometimes lower than expected. For

example, in 1982, rainfall at one Mississippi Nursery averaged more than 90 mm per week (from November 16 until December 10). Lifting began on December 9<sup>th</sup> with subsequent widespread mortality. Mortality increased when seedlings were kept in refrigerated storage for longer than a week (Oak 1983). As the lifting season progressed, seedling performance gradually improved. By mid-February, seedlings appeared to be fully recovered.

Two incidences occurred in 1994 in Alabama and Georgia. Rainfall at a Georgia Nursery during the month of October averaged 59 mm per week. From November 11<sup>th</sup> until December 5<sup>th</sup> rainfall averaged 65 mm per week. Lifting began on November 23<sup>rd</sup> and by January 20 all seedlings on some sites were dead. By that time seedlings remaining in K-P bags had black and mushy roots.

In 1997, above average rainfall occurred at a nursery in Alabama and seedlings lifted from December 3<sup>rd</sup> to December 15<sup>th</sup> exhibited poor survival. During the previous month, rainfall averaged 45 mm per week. Although the low performance of seedlings lifted during this period might be attributed solely to the “December Dip,” we believe the above average rainfall in November exacerbated the problem.

In addition to the excessive rain, two other factors might contribute to lowering oxygen levels in nursery soil: above average temperatures and fertilization in October or November. It is well known that injury from flooding is greater when soil temperatures are higher (Kozlowski 1884; 1986). Warm water contains less oxygen and soil microbes are more active (microbial respiration is at a higher rate). Therefore, excessive rains in a warm November would be more harmful than the same amount of rainfall in January.

Problems associated with excessive rainfall are not new. Wakeley (1954) stated “In a year of extraordinary weather conditions, severe late fall or early winter drought might reduce survival; or excessive fall rain might reduce it by lowering the physiological quality of the nursery stock.” Henry (1953) reported on a root rot in Mississippi where the cause of the problem was unknown (possibly nematodes). However, the problem was most severe in low areas of relatively poor drainage and lenticels on diseased seedlings were sometimes enlarged (Henry 1953).

When nursery managers record above average rainfall in November and early December, they may want to check their seedlings for signs of root injury before lifting. Lenticels on the taproot is one indicator of waterlogged conditions. It may be advisable to delay lifting seedlings until February (to allow the roots time to recover). Managers should first consider lifting from well-drained areas where seedlings have healthy mycorrhizal roots. Anaerobic soil conditions can kill white root tips as well as mycorrhizal roots (Gadgil 1972).

Although studies have been conducted on the effects of flooding or waterlogging on roots in situ, few studies have transplanted seedlings soon after a waterlogging treatment. In one study, Wakeley (1954) reported a 15% decrease in survival after just one day of storing pine seedlings in tubs of water. Our assumptions regarding survivability have been based only on observations from plantation failures. Therefore, research is needed to determine the length of time required before anaerobic conditions cause problems with transplanting. In addition, nursery managers need a simple test (such as electrolyte leakage) that could be used prior to lifting to evaluate the health of roots.

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