auburn university
southern forest nursery
management cooperative

RESEARCH NOTE 97-1

USE OF FLUOROMETRY IN ASSESSING POTENTIAL SURVIVAL IN RESPONSE TO COLD STORAGE DURATION IN LOBLOLLY (*P. taeda* L.), LONGLEAF (*P. palustris* M.) AND SLASH PINE (*P. elliottii* E.)

by
Kristal Tucker, Lisa Samuelson, and Ken McNabb

INTRODUCTION

Chlorophyll fluorescence (Fv/Fm) may be used to indicate seedling quality when a decline in seedling performance is related to stress induced damage to foliage (McNabb et al. 1995. Auburn University Southern Forest Nursery Management Cooperative. Research Note 95-5). Because there may be considerable stress associated with cold storage, fluorescence has the potential to provide a physiological assessment of seedling quality in nursery practices. The objective of this work was to determine if fluorometry can be used as an indicator of seedling survival in response to cold storage duration in loblolly, longleaf and slash pine.

METHODOLOGY

In November of 1995 and January of 1996, 40 loblolly, 40 longleaf, and 40 slash pine seedling were lifted from the Flint River Nursery in Montezuma, GA. Initial (zero month) chlorophyll fluorescence measurements (CF-1000 Chlorophyll Florescence Measurement System, Morgan Scientific, Inc. Haver Hill, MA) were taken immediately prior to lifting. The seedlings were stored in kraft-polyethylene bags at 4° C for 1, 2, and 3 months. At the end of each month, chlorophyll fluorescence was measured on 10 seedlings of each species. The same 10 seedlings were planted in sand-filled pots (646 cm^3) and the pots then planted in the trophotron in Auburn. The trophotron is an outdoor concrete lined sand pit. The seedlings were watered every other day for one hour. Percent survival for all seedlings was tallied in July of 1996.

RESULTS

As is usually the case in these types of studies, storage date is confounded with planting date. Unfortunately, several weather and environmental factors conspired to give planting date an important influence on the results and it is hard to separate the effect of storage from the effect of planting date.

Loblolly:

Both survival and fluorescence declined over storage time for Loblolly pine (Figure 1). The November lifting date showed very poor survival for 1, 2, and 3 months storage (40 to 30%). The fluorescence values declined during storage as well, falling from an Fv/Fm ratio of .661 at the time of lifting (0 storage) to . 60 after 3 months in storage. The January lift had much better survival (100 to 60%) and with one exception, fluorescence generally declined with survival. The very low fluorescence values of the 0 storage date for the January lifting was probably due to the very low temperatures at the time of measurement.

Longleaf

The survival results for November lifted Longleaf is very difficult to interpret. One month storage resulted in 0% survival, while a storage of 3 months resulted in 40% survival. There is no explanation for this. As with Loblolly, fluorescence declined with storage time although the decline was statistically significant only for the November lift.

The Longleaf January lift was the one case in this experiment where fluorescence was directly correlated to decreasing survival. The trend is obvious, with declines in survival caused by increasing length of storage. The decrease in survival was in turn associated with declines in fluorescence, where Fv/Fm ratios declined from .68 to .615 during three months of storage.

Slash

Results for Slash were similar to those of loblolly with November lifted seedlings surviving very poorly. If fluorescence declined with storage time, the trend was very weak. January lifted seedlings survived much better with average survivals at 70% even after 3 months in storage. As in the case of Loblolly, the anomalous florescence value for the 0 storage of the January lift date (Fv/Fm ratio of .571) was probably due to low temperatures at the time of measurement.

MANAGEMENT IMPLICATIONS

Research in 1995 indicated that chlorophyll fluorescent might be used to indicate freezing damage to loblolly pine seedlings. At this point, however, we do not believe that fluorescence will be a practical field indicator of seedling quality as influenced by storage. First, although seedling survival generally declined during long term storage, fluorescence declined a relatively small amount during that time. Such small differences would be difficult to interpret as a measure of seedling quality. Secondly, we did not find that fluorescence correlated directly to survival.

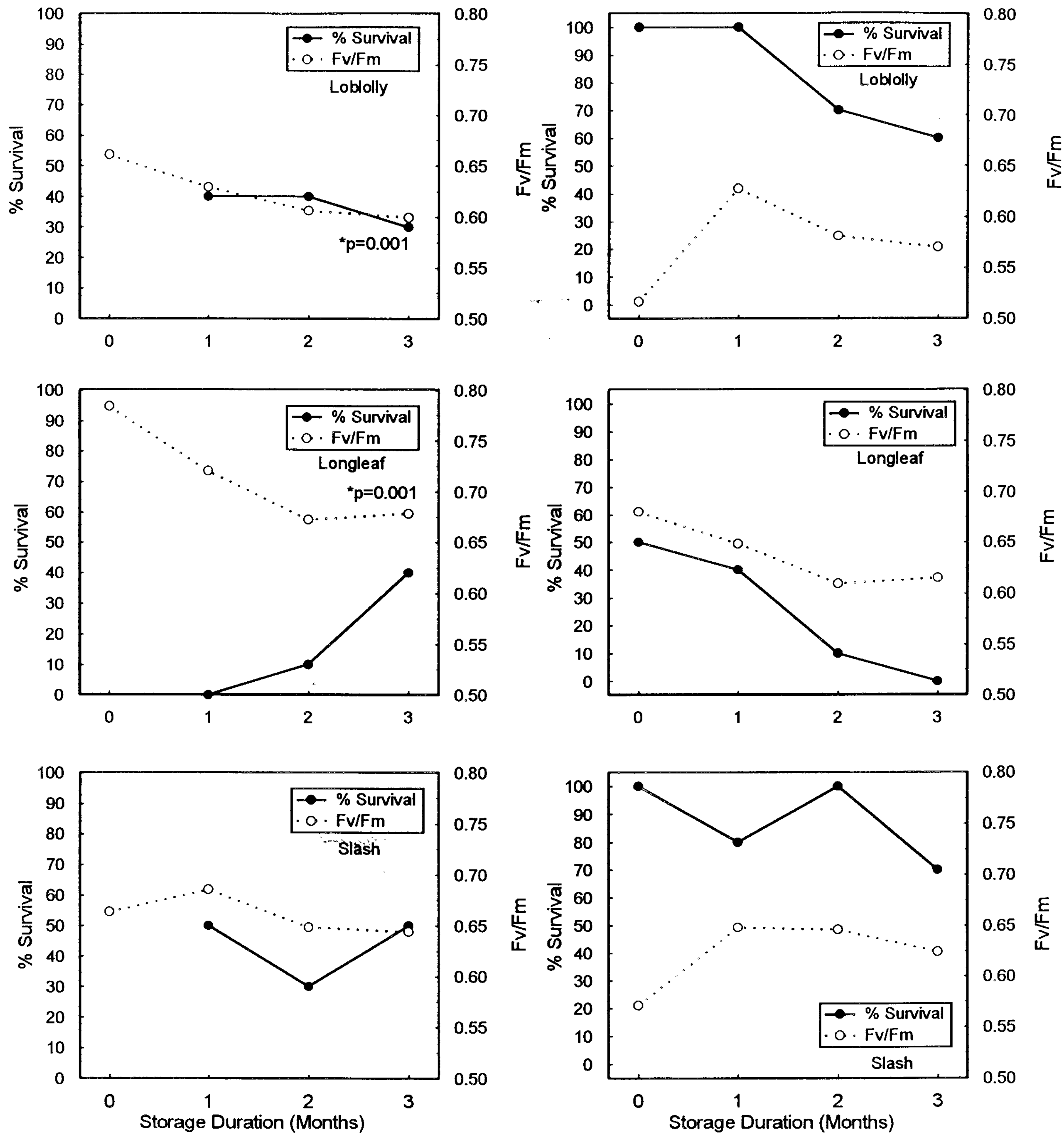

Figure 1. Relationship between cold storage duration and survival or Fv/Fm of loblolly, longleaf and slash seedlings lifted in November (left) and January (right). No survival data for seedlings lifted in November are presented for storage at 0 months due to experimental error. * indicates a significant linear decline in Fv/Fm with increasing cold storage duration.

AUBURN UNIVERSITY
SOUTHERN FOREST NURSERY MANAGEMENT COOPERATIVE

RESEARCH NOTE 95-5

DETERMINING LOBLOLLY PINE (*P. taeda* L.) SEEDLING QUALITY BY CHLOROPHYLL FLUORESCENCE

Ken Mc Nabb, Lisa Samuelson, and Kristal Tucker
School of Forestry, Auburn University, Auburn, Alabama, U.S.A. 36849-5418

INTRODUCTION

Plant chloroplasts absorb light energy and transform this energy through photosynthesis into chemical products basic to plant growth and development. Not all of this energy, however, is transformed into the chemical products of photosynthesis. Some light energy absorbed by the chlorophyll pigment is re-emitted in the red portion of the spectrum and is known as chlorophyll fluorescence. Theoretically, chlorophyll fluorescence can be used as an indicator of plant health as changes in fluorescence could indicate damage to the photosynthetic mechanism resulting from environmental stress. Because there is considerable stress to seedlings associated with the lifting, storage, transporting, and planting process, fluorometry has the potential to provide a physiological assessment of seedling quality. Much of the work with fluorescence as an indicator of seedling quality has been done on temperate and boreal species. This work reports on a series of experiments investigating the possibilities of using chlorophyll fluorescence for the assessment of seedling quality in loblolly pine (*Pinus taeda* L.), the principle species planted in the southeastern U.S.

METHODOLOGY

Water Stress Study - Recently lifted loblolly pine seedlings were placed in cold storage (5°C) and water-stressed by exposing the entire seedling to air for a duration of four to 14 days to produce a range in Fv/Fm (quantum yield - an expression of fluorescence) values from 0.37 to 0.66. Water potentials were < -3.5 MPa in all water-stressed seedlings. Fv/Fm ratios were measured on upper and lower needles on a total of 30 seedlings subjected to water stress. After treatment, water-stressed seedlings were planted in pairs with control seedlings in separate pots with a sand medium and placed in a greenhouse. Survival and height growth were measured four weeks following planting.

Freezing Study - Seedlings taken from two weeks in cold storage were subjected to freezing temperatures (-5 to -10 °C) immediately before planting by placing seedlings in a chest freezer for 30 or 60 minutes (n=20 per treatment). Roots were protected by submerging the root system in a bucket of water during the freezing period. Fv/Fm ratios were measured on an upper and lower needle of each seedling after exposure to freezing temperatures and acclimation to room temperature. Stressed seedlings were planted in pairs with control seedlings in separate pots with a sand medium and placed in a greenhouse. Survival and height growth were measured four weeks following planting.

Leaf Photosynthesis or Height growth - The relationship between Fv/Fm and leaf photosynthesis or height growth was measured in 40 seedlings kept in cold storage for one month. Fv/Fm values of upper and lower needles were measured immediately before seedlings were planted into pots with a sand medium and placed in a greenhouse. Net photosynthesis of upper and lower needles was monitored over a four week period until maximum rates were achieved. Height growth was measured at four weeks.

RESULTS

Water Stress Study - The range in Fv/Fm ratios for water stressed seedlings was from .37 to .60 ($\bar{x}$ =.51) while unstressed seedlings ranged from .56 to .65 ($\bar{x}$=.61). Despite the range in Fv/Fm values, all seedlings exposed to water stress died and thus exhibited no height growth (Figure 1). Therefore, no relationship between Fv/Fm ratios and performance was observed. Although the entire plant was water stressed, the roots undoubtedly desiccated more quickly than the shoot resulting in extensive root mortality and disfunction.

Freezing Study - Fv/Fm ratios ranged from .41 to .65 ($\bar{x}$=.58) in seedlings exposed to 30 minutes of freezing, while ratios ranged from .20 to .53 ($\bar{x}$=.34) in seedlings exposed to 60 minutes of freezing. Control seedlings exhibited Fv/Fm values in the range of .47 to .69 ($\bar{x}$=.59). In contrast to the water stress study, Fv/Fm values of seedlings exposed to freezing temperatures before planting were correlated to the percentage of dead needles on a seedling (Figure 2) and height increment (Figure 3). R^2 values of .60 for both dependent variables indicated substantial predictability of seedling performance based on fluorescence. In this case, freeze induced damage to foliage resulted in lower fluorescence ratios probably due to impaired photosynthetic mechanisms. This damage translated into reduced seedling performance after transplanting.

Leaf Photosynthesis or Height growth - Fv/Fm values of seedlings ranged from .48 to .70 and averaged .60 after 4 weeks of cold storage and measured immediately before planting. However, the Fv/Fm ratio explained only a small amount of the variation in foliar net photosynthesis (Figure 4) and height growth, though the models were statistically significant for both variables. A number of seedling related factors such as carbohydrate status, genetic source, and stress before storage may influence seedling performance after planting. Seedling size, for example, is strongly correlated to seedling health and performance. The relationship among seedling morphology, physiology, and environmental stress is complex and will likely affect the utility of fluorescence as a tool in the assessment of physiological quality.

MANAGEMENT IMPLICATIONS

This first study indicates that Chlorophyll fluorescence (Fv/Fm) may be used to indicate seedling quality when a decline in seedling performance is related to stress induced damage to foliage. For example, seedling mortality caused by freezing was indicated by chlorophyll fluorescence before it became visible on the seedling. On the other hand, environmental stresses negatively affecting the roots will very likely decrease seedling quality but will probably not be effectively detected by fluorescence techniques.

The utility of chlorophyll fluorescence as an indicator of loblolly pine seedling quality deserves further work. It is plausible that decreasing seedling quality associated with long term storage may be measured by Chlorophyll fluorescence. This possibility needs to be investigated.