

# The Impact of Fertilization and Throughfall Exclusion on Loblolly Pine Growth and Water Use

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## Study Design

The study design is a randomized complete block containing two levels of fertilization and throughfall exclusion in a 2x2 factorial arrangement. Treatments include: fertilization with 224N, 28P, 56K (kg/ha) and micronutrient blend as to eliminate any nutrient deficiencies, and an exclusion of 30% of incoming throughfall. The factorial design results in four individual treatment types. Each individual treatment type was replicated four times for a total of 16 plots. Treatment types include:

- 1) **Control (C):** ambient throughfall, no fertilizer
- 2) **Fertilization (F):** ambient throughfall, fertilization
- 3) **Throughfall Exclusion (D):** throughfall exclusion, no fertilizer
- 4) **Fertilization and Throughfall Exclusion (FD):** 30% throughfall exclusion, fertilization.

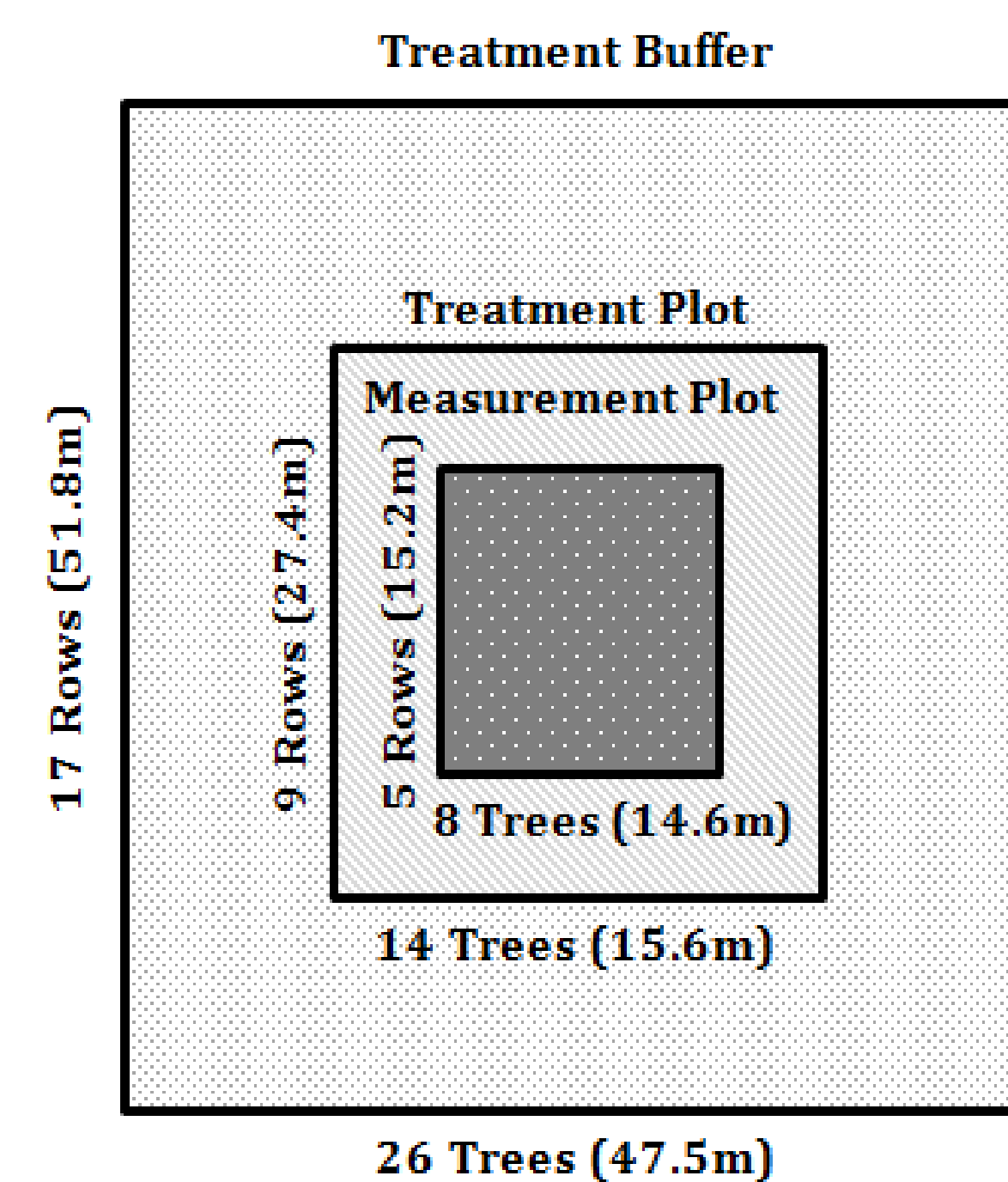


Figure 2. Design of treatment plots

## Methods

An inventory of all trees in measurement plots was conducted in the spring of 2012 before treatments were applied to assess baseline conditions. Treatments were applied in April of 2012 and all plots were treated with herbicide to remove competing vegetation. An additional inventory was conducted in the winter of 2013 in order to assess the impact of treatments on stand growth. Inventories included measurements of diameter at breast height (DBH, ~1.4m) and total tree height.

Transpiration was measured on five trees per plot from August 7<sup>th</sup>, 2012, to February 26<sup>th</sup>, 2013, using heat dissipation sap flow probes as described by Granier in 1987 (Figure 5). Measurement trees were selected using the "quantiles of total" technique (Cermák and Michálek 1991). This technique skews the sample distribution toward the larger diameter trees which tend to dominate stand transpiration. Canopy transpiration was calculated using the proportion of measurement tree sapwood area to total plot sapwood area. Measurements were taken every 10 seconds and half hour averages were stored on data loggers.

A weather station was installed at the site to measure photosynthetically active radiation, temperature, relative humidity and precipitation. All sensors were measured every minute and half hour averages were collected on data loggers. All analyses were conducted using SAS version 9.3.



Figure 5. Sap flow probe in loblolly pine stem

## Results

The results of this study suggest that a 30% reduction in throughfall does not significantly affect the growth or water use of loblolly pine plantations in a single year. The throughfall exclusion treatment did not significantly impact height growth ( $p = 0.41$ ) or basal area production ( $p = 0.36$ ). Mean daily transpiration was also found to be unaffected by throughfall exclusion ( $p = 0.68$ ). Precipitation during the measurement period was above the long-term average for its region and may have influenced these results. It is likely that the continued reduction of incoming throughfall in subsequent years will result in more apparent differences.

The application of fertilizer was found to increase growth and water use of loblolly pine. Basal area growth was found to be significantly higher in stands that received fertilizer ( $p = 0.05$ ), however there was no apparent impact of fertilization on height growth ( $p = 0.84$ ). Plots that received fertilizer were also found to have higher rates of mean daily transpiration although this relationship was not statistically significant.

Leaf area index (LAI) provides a measure of the evaporative surface within the canopy. Fertilizer application has been shown to increase the LAI of loblolly pine stands by 2 fold (Albaugh *et al.* 1998). It is likely that the higher rate of water use in fertilized stands is the result of increases in LAI and that these differences will become more pronounced as the stands continue to grow. This suggests that, under drought conditions, the use of fertilizer has the potential to increase water stress in loblolly pine plantations.

## Introduction

Over the last 60 years the productivity and extent of pine plantations in the Southeast United States has dramatically increased. From 1952 to 2000, the area of pine plantations in the Southeast increased from 0.7 million hectares to 13 million hectares (Wear and Greis 2002). During this period the mean annual increment of southern pine plantations has more than doubled while rotation lengths have decreased by more than 50% (Fox *et al.* 2007). This increase in productivity is largely due to the implementation of site preparation, fertilization, herbaceous weed control, density management, and genetically improved planting stock.

Loblolly pine (*Pinus taeda*) is often intensively managed in the Southeastern United States and is the nation's leading timber species (Schultz 1997). The influence of climate change on temperature and precipitation patterns in the Southeast U.S. will likely have an important impact on the productivity of loblolly pine plantations. The Southeast is predicted to experience an increase in average temperature of 2.5 to 5°C by the 2080s (Karl *et al.* 2009). Predictions for changes in precipitation, although less certain, generally indicate a 10% to 30% reduction in summertime precipitation (Karl *et al.* 2009, Christensen *et al.* 2007). Increased average temperature and decreased precipitation will increase vapor pressure deficits (VPD). Potential increases in VPD will likely impact forest tree water use. The objective of this study is to quantify the impact of fertilization and throughfall exclusion on loblolly pine water relations and productivity.

Table 1. The impact of treatments on Height and Basal Area Growth

Treatment	Average Height 2012 (m)	Average Height 2013 (m)	Height Growth (m)	Basal Area 2012 (m <sup>3</sup> /ha)	Basal Area 2013 (m <sup>3</sup> /ha)	Basal Area Growth (m <sup>3</sup> /ha)
C	10.2	11.4	1.2	21.3	25.3	4.0
D	10.8	12.0	1.2	21.3	25.1	3.8
F	10.6	11.8	1.2	21.6	26.4	4.8
FD	10.7	11.9	1.3	22.0	26.5	4.4

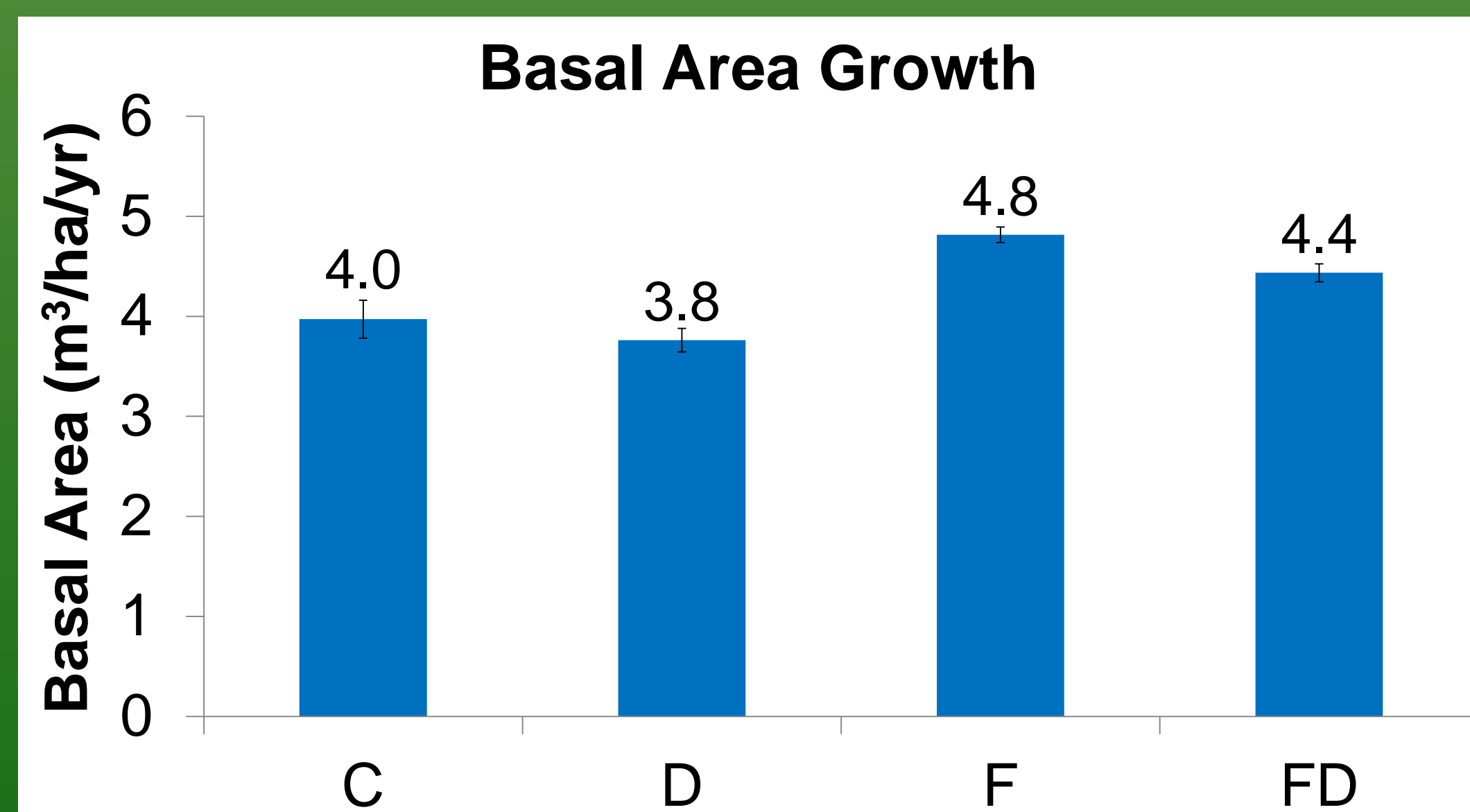


Figure 3. Mean basal area growth by treatment

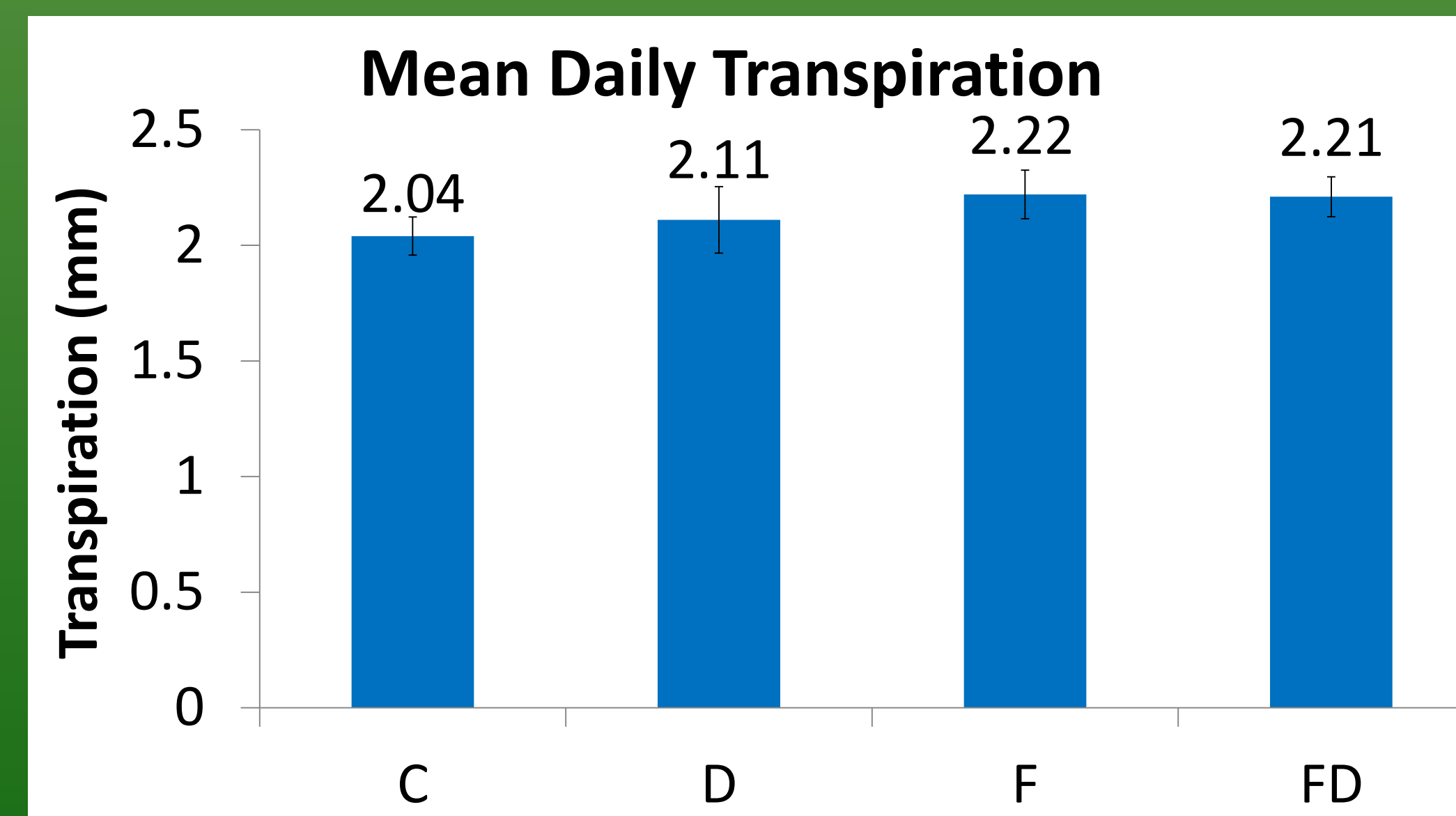


Figure 4. Mean daily transpiration by treatment