The effects of water stress on variability in mesophyll conductance of loblolly pine (*Pinus taeda* L.) leaves

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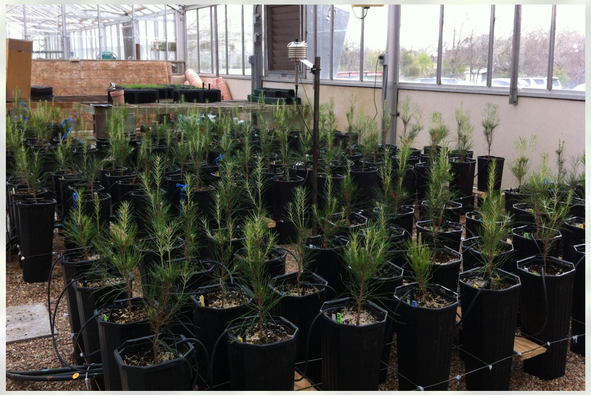
Introduction

Climate models predict changing precipitation regimes and a decrease in moisture availability to forests in the Southeastern US. Breeding for drought tolerance in *Pinus taeda* L. (loblolly pine) is important for continued productivity and mitigation of rising CO_2 levels by carbon sequestration. Carbon stable isotope analysis has been used as a proxy for water use efficiency (WUE) in breeding and ecophysiology. However, the long-standing model does not include variability in mesophyll conductance to CO_2 (g_m).

Recent studies have shown evidence that g_m varies with several environmental conditions. The capacity of a plant to control g_m independently of stomatal conductance (g_s) could enable it to assimilate more carbon relative to other plants with similar carbon-13 isotope ratios ($\delta^{13}C$).

Objectives

- Measure **gas exchange and instantaneous carbon isotope discrimination simultaneously** to estimate g_m differences between leaves developed under different water regimes
- Estimate **g_m responses at different light levels** to analyze the effect of water stress on the capacity of three clonal varieties to control g_m



Rooted cuttings of *P. taeda* clones being grown in a greenhouse.

References

Baltunis, B., T. Martin, et al. (2008). "Inheritance of foliar stable carbon isotope discrimination and third-year height in Pinus taeda clones on contrasting sites in Florida and Georgia." Tree Genetics & Genomes **4**(4): 797-807.

Evans, J. R. and S. von Caemmerer (2012). "Temperature response of carbon isotope discrimination and mesophyll conductance in tobacco." Plant, Cell & Environment.

Methods

Greenhouse study

We established a greenhouse study using a randomized complete block design. The factors are:

- Five clonal varieties of *P. taeda*
- Three water treatments

There are ten replicates of each treatment for a total of ten blocks.

Example of randomized complete block
1-5: clonal varieties
- Well-watered
- Moderate water stress
- Severe water stress

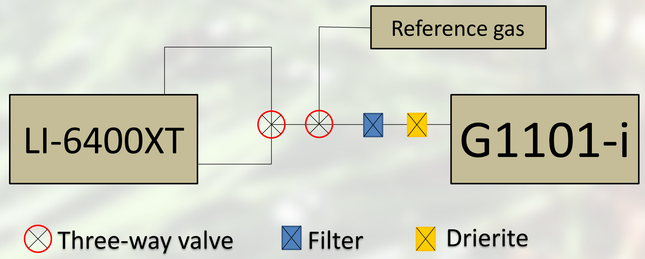
Preliminary bulk leaf carbon isotope analysis

Leaf samples from five individuals of each of the five clones were collected, prepared, and analyzed for baseline carbon isotope ratios before treatments were induced.

Preliminary gas exchange measurements

Gas exchange measurements were taken at varying CO_2 concentrations in order to construct A/c_i curves for each clonal variety. The LI-6400XT system (LI-COR, Lincoln, NE) was used for gas exchange, and the standard chamber with LED light source and needle chamber were each used for comparison.

Schematic of coupling LI-6400XT gas exchange system to G1101-I cavity ring-down spectroscopy laser



Estimation of g_m

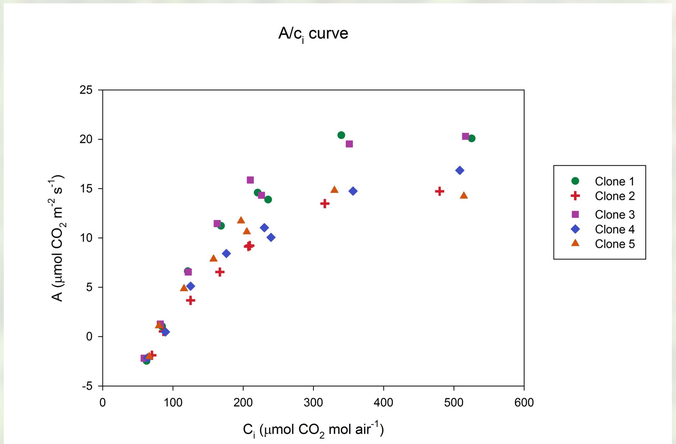
We will couple the LI-6400XT system to the G1101-i cavity ring-down spectroscopy laser (PICARRO, Santa Cruz, CA) to make simultaneous gas exchange and carbon isotope discrimination measurements at varying light levels. From this data, g_m will be estimated using the equations derived by Evans and von Caemmerer (2012).

Preliminary Results

Preliminary bulk leaf carbon isotope analysis

	Average δ13C (‰)	Min (‰)	Max (‰)	Standard deviation
clone 1	-31.65	-32.03	-31.36	0.257
clone 3	-31.28	-32.10	-30.85	0.509
clone 5	-31.22	-31.89	-30.57	0.559
clone 2	-31.00	-31.64	-30.35	0.555
clone 4	-30.73	-31.51	-30.14	0.447

Preliminary gas exchange measurements



Discussion

Another study of *P. taeda* (Baltunis et al, 2008) found mean ^{13}C discrimination values of 21.2‰ and 19.6‰ at two field sites. Our baseline $\delta^{13}C$ values had a similar range of discrimination between clones, and the very negative values are indicative of greenhouse-grown stock that received recirculated, depleted air and adequate water.

The preliminary A/c_i curve indicates that clones 1 and 3 had higher maximum photosynthesis rates than the other three clones. Clones 1 and 3 also had the most negative baseline $\delta^{13}C$. However, the gas exchange measurements should be replicated for further analysis.

The results of this study will be compared to leaf carbon isotopes of loblolly pines in a field study with throughfall excluders to scale leaf-level physiology to whole plant WUE. This experiment will advance our understanding of the controls on g_m and allow us to evaluate the accuracy of our current carbon isotope models.

Acknowledgements

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