SAND2015-9306C

The effects of reorientation on the photosynthesis of poplar leaves

Michael Bennett, Jerilyn Timlin, Keith Lidke, David Hanson

Introduction

The anatomy of a leaf works hand in hand with the biochemistry to maintain homeostasis within a leaf; while a mature leaf's anatomy cannot be altered, it may be possible to alter its biochemistry and its photosystem function. This leads to the question, how can we perturb leaf biochemistry? Over the course of this summer, several tests were initiated involving reorientation of poplar leaves to identify correlated changes in biochemical behavior and photosynthetic function. Leaf reorientation was found to impair photosystem function when measured as optimal quantum yield, but did not alter chlorophyll content or photosynthetic carbon assimilation.

Methods

Mature poplar leaves were flipped upside down and pinned so that incident light would enter the bottom of the leaf rather than the top. The reoriented leaf was compared to two control orientations; one was left in its natural orientation which was slightly vertical. The other was pinned horizontally so it would remain constantly in the sunlight (Figure 1a).

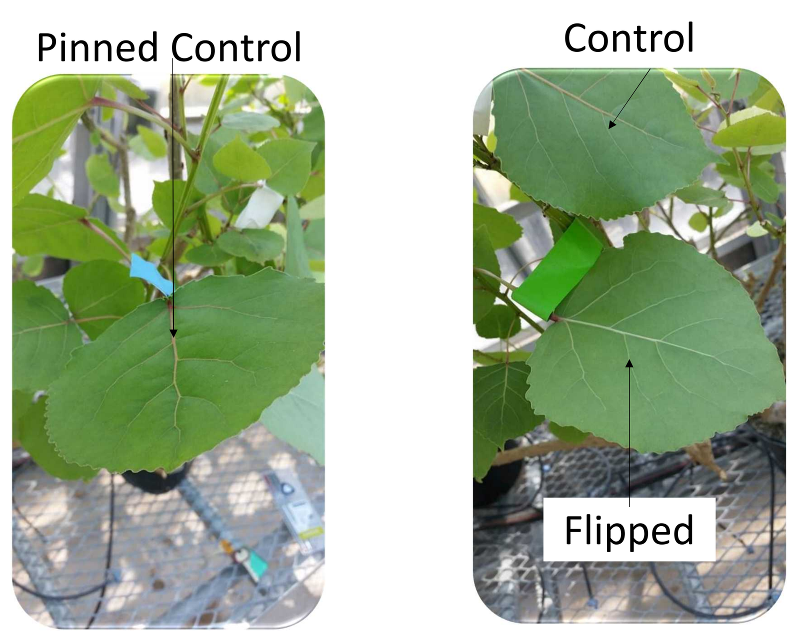


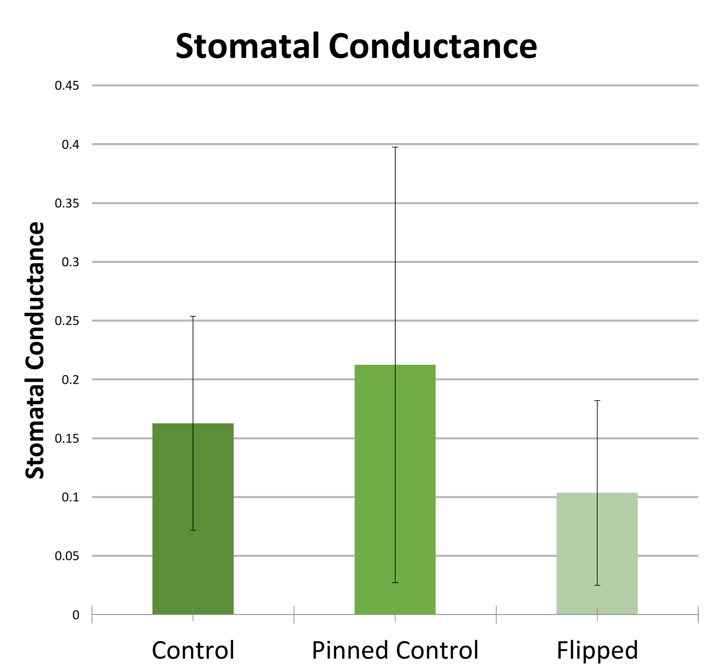
Figure 1. a.) Pinned Control b.) Control (top) and Flipped (bottom)

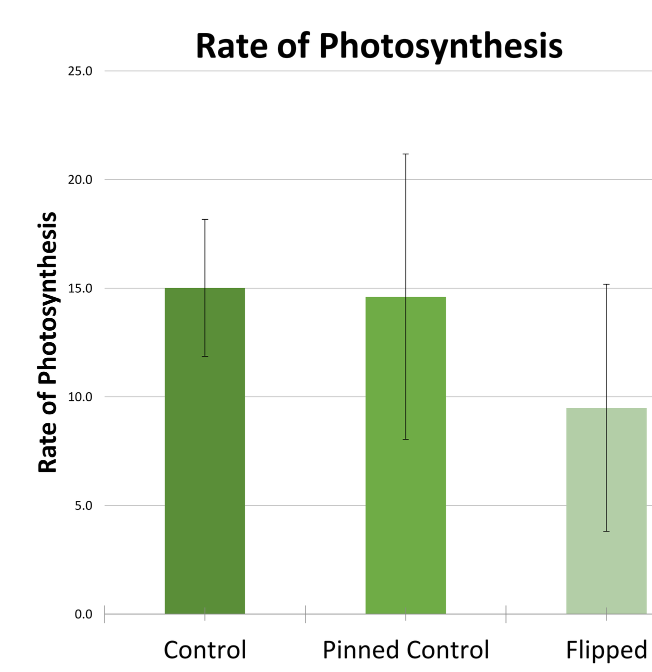
The leaf's photosynthetic function was measured using a portable gas exchange system (LI-COR, Lincoln, NE) which measures CO_2 uptake for photosynthesis and water loss for stomatal conductance of the leaf (Figure 2a). A spectrophotometer was used to measure the amount of chlorophyll a and b in a fresh leaf extract (Figure 2b). PAM (Pulse Amplified Modulation) fluorescence was also used to determine photosynthetic electron transport, reported here as both effective and optimal quantum yield (Figure 2c).

Figure 2. a) Gas exchange data are collected in the rooftop greenhouse. b.) Chlorophyll extracts. c.) Effective quantum yield data is collected in the light then the leaves are dark adapted before optimal yield is taken.

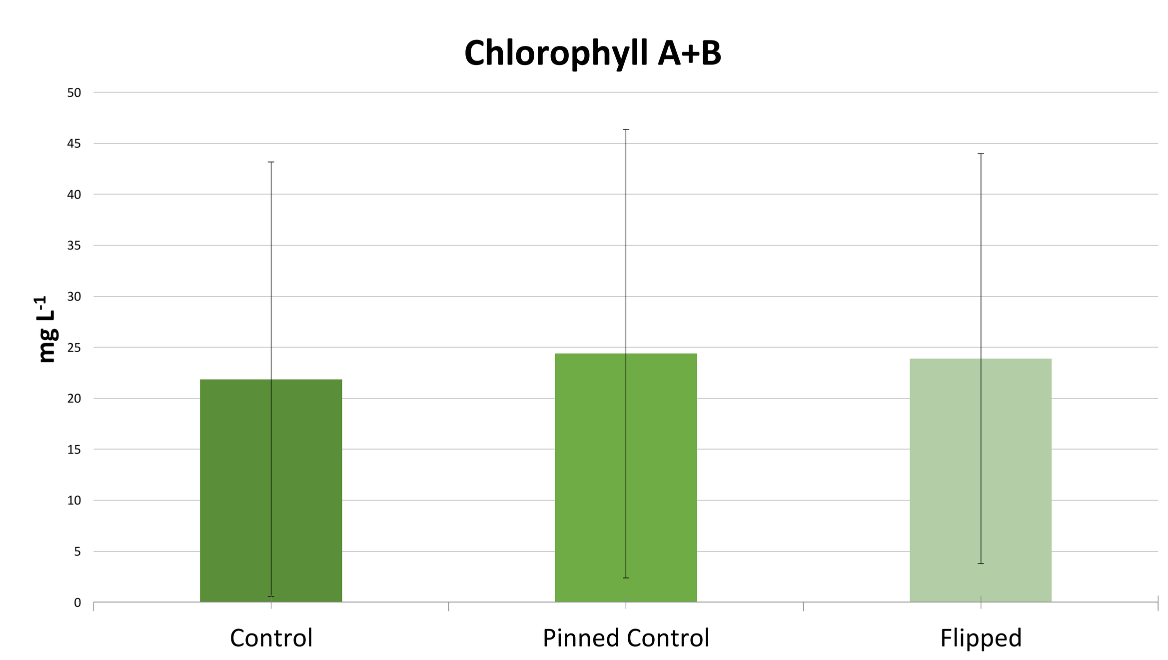
Results & Graphical Data

Data from these three different tests indicated that the flipped orientation had little effect on photosynthesis. The as exchange data recorded that mean stomatal conductance in the leaf was less than that of the two control orientations. However, this was not statistically significant since the standard deviation betweenleaves was a large.

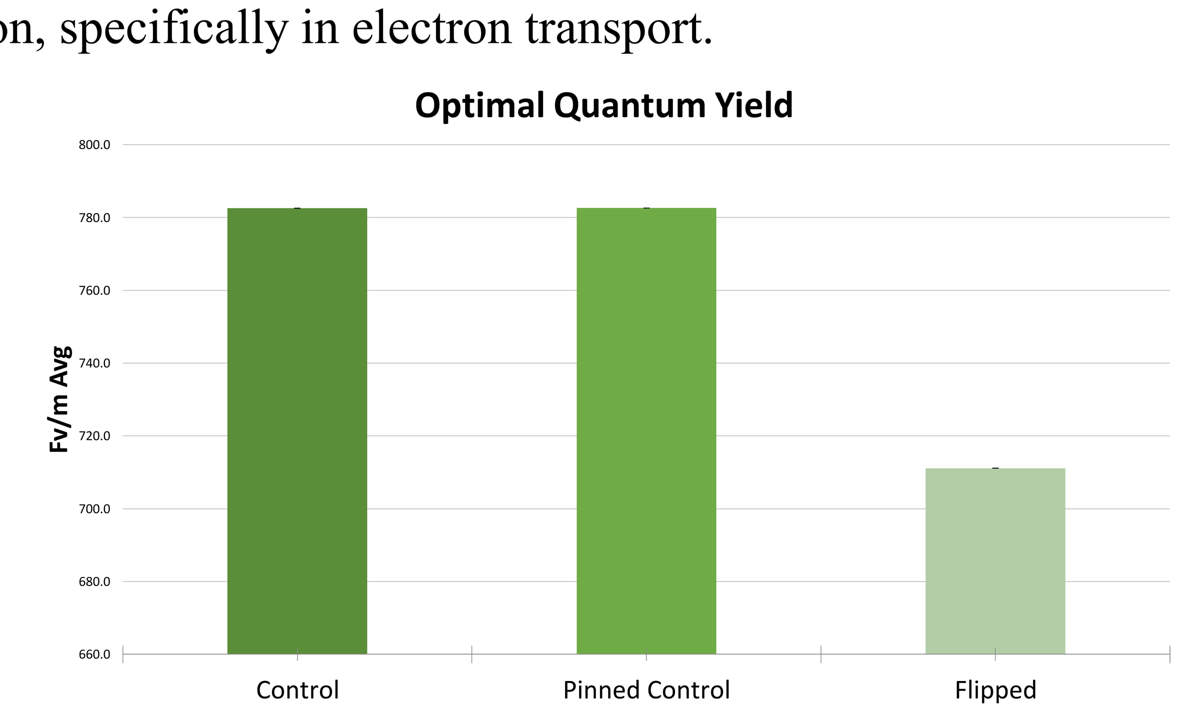




Chlorophyll a and b content in the leaf of the flipped orientation was not different from the two control leaves. Again there was a great deal of variation among leaves.



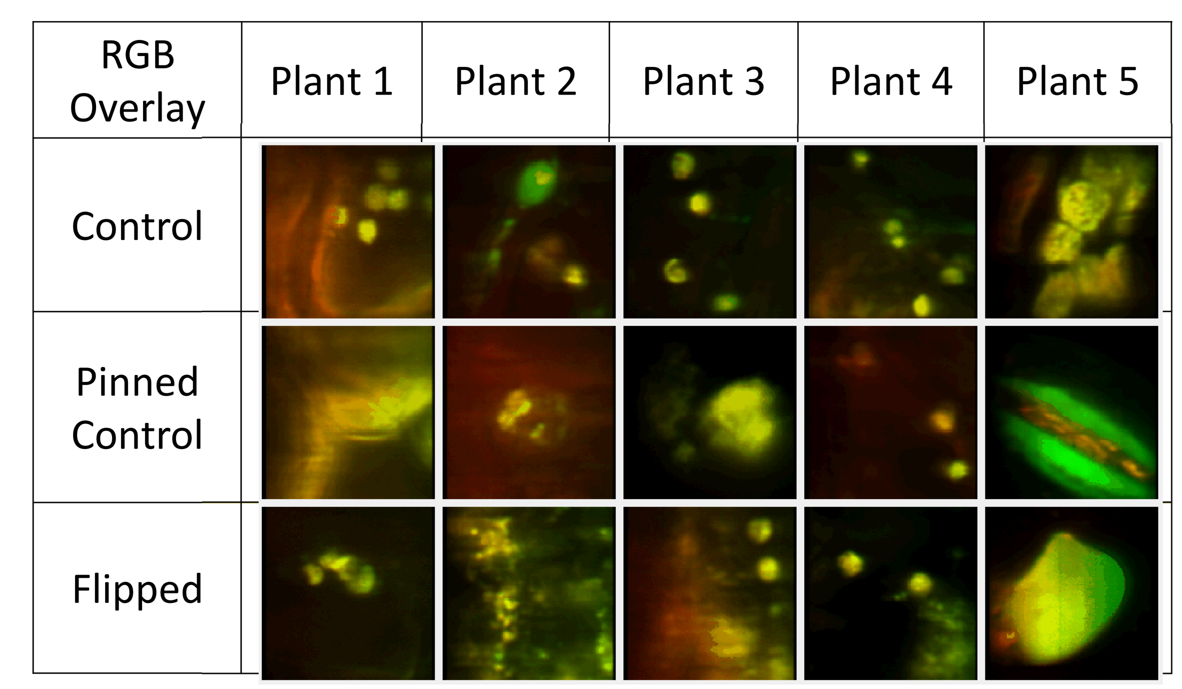
Interestingly, data from the PAM tests showed a considerable decrease in the flipped leaves optimal quantum yield, a sign of impaired biochemical function, specifically in electron transport.



Hyperspectral Imagery

We used hyperspectral imaging to collect a full visible spectrum in each pixel of the cells being imaged. Below is a set of images taken of each different oriented leaf. Our goal was to look for changes in pigment composition through the thickness of the leaf. However, we are still refining methods to see distribution of beyond a few cells. All Images are NOT on same color scale. It's autoscaled min to max for each image to highlight the differences between images. Images are 15µm by 15µm

Green = ChlB, red= ChlA



Picture Courtesy of Dr. Jerilyn Timlin and Sandia National Laboratories

Conclusion and Future Direction

In conclusion, reorientation of the poplar leaf caused minor changes in whole leaf physiology, possibly because leaves of these plants are often not oriented horizontally during development. Use of a different species with more uniform orientation or reorienting leaves while they are younger would be more informative. This would allow us to record the photosynthetic function over a longer period of time and see if it correlates with the data observed over this summer.

We also intend to improve our methods enough to take a cross section of a leaf and, using hyperspectral microscopy, image the leaf across its entire gradient so that the biochemical composition inside the leaf could be visualized and quantified.

Acknowledgments

I would like to cordially thank everyone who gave me the chance to conduct this research especially Coda Omness, Dr. Linnea Ista, Lyndsay Ryan, Jennifer Thompson, Shaleen Day, John Roesgen and all the graduate and undergraduate students in Dr. Hanson's lab and Dr. Lidke's lab for helping and guiding me in my research over the summer; Chelsea Chee, Dr. Michael Heagy and the rest of New Mexico EMPSCoR for choosing me to be apart of this amazing program, and finally Sandia National Labs.

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.