Role of Trichomes in Regulation of Optical Properties in Carya glabra and Carya ovata

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Abstract

Trichomes – leaf hairs – have many functions including herbivore and radiation defense as well as temperature and water regulation. While trichome function and purpose is well understood most research has been done on adaxial trichomes, while little is known about the function of abaxial trichomes. We hypothesized that the purpose of abaxial trichomes is to re-reflect transmitted light back into the leaf to optimize light efficiency and increase the amount of photons going into the leaf. We observed two lines of hickory trees - *Carya glabra* (Pignut, glabrous) and *Carya ovata* (Shagbark, pubescent) – and looked at the optical properties of the abaxial surface, gas exchange values, and leaf mass. We found that while neither the pignut nor shagbark lines differed in either stomatal conductance (p=0.871) or leaf mass/area (p=0.302), pignut leaves had higher photosynthetic rates than shagbark, 9.00 micromol CO_2 m^2 s^{-1} (SE=+/-0.315) and 7.40 micromol CO_2 m^2 s^{-1} (SE=+/-0.190) respectively (p=0.0001). Shagbark had higher reflectance and transmittance values than pignut between wavelengths 450-700 nm (P<<0.05), while pignut had greater absorptance than shagbark between wavelengths 513-604 nm and 694-700 nm (P<0.05). There is a clear difference between the optical properties of pignut and shagbark trees, however future experiments must be conducted where the leaves are manipulated to confirm whether or not trichomes are contributing to this difference.

Introduction

Trichomes are small hair-like structures found on many plant surfaces. There are two kinds of trichomes – glandular, which contain defense compounds, and non-glandular. Both kinds of trichomes are important for both herbivore and pathogen defense. Other functions include UV protection and water regulation both in the interior and on the exterior of the leaf (Bickford 2016). We were interested in non-glandular trichomes to see if their presence had an impact on the optical properties of plant leaves.

Methods

We found four glabrous and five pubescent hickory trees outside and collected samples. We cut multiple branches off each tree then immediately trimmed about 2 inches off the bottom of each branch to remove any embolisms created during the initial cut. This allowed the branches to continue on with normal photosynthetic rates as well as stomatal conductance after being cut.

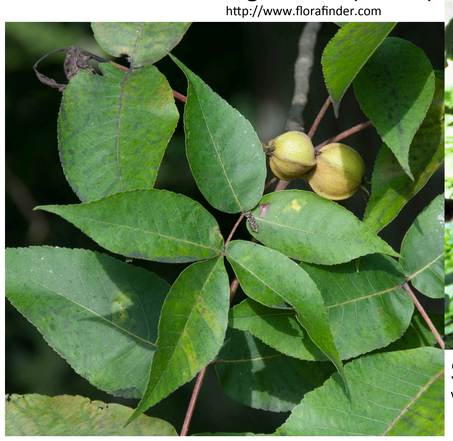
Optical properties of the leaves - reflectance, transmittance, and absorptance - were measured using a Jaz-TR-Spectroclip (Ocean Optics).

Photosynthetic and stomatal conductance measurements were taken using an LI-6400XT Li-Cor Biosciences based on the CO_2 flux.

Leaf mass samples were collected using a 1.04 cm circumference leaf punch. Samples were dried for 24 hours and weighed.

Leaf shaving methods were experimented with using scotch tape, masking tape, generic razor blades, and optical knives of various sizes ranging from 1.2-1.8 mm. We experimented with various methods on both the adaxial and abaxial surfaces.

Pignut leaf (below)
http://www.florafinder.com



Shagbark leaf (above)
www.extension.iastate.edu

Results

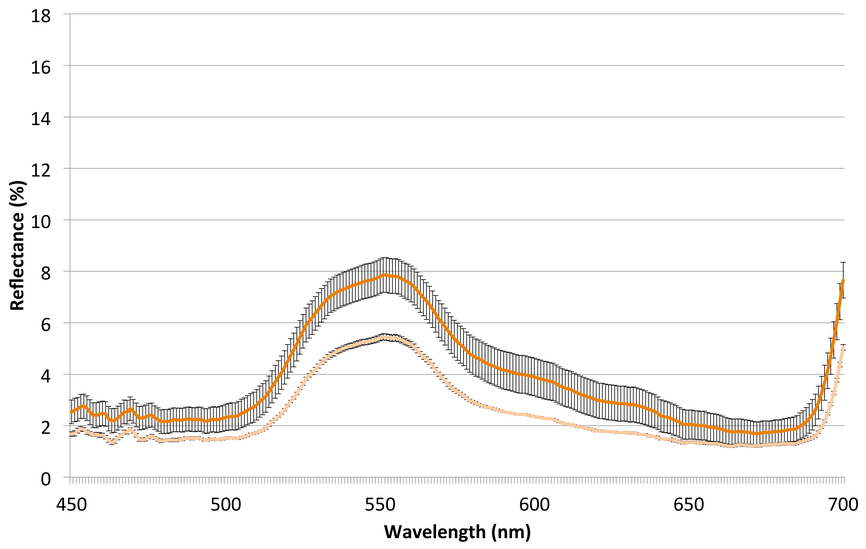


Figure 1. Reflectance of light on the abaxial surface of the leaves. The light orange line represents glabrous leaves while the dark orange represents pubescent leaves. 2-Sample T-Test, Error Bars = SEM, p << 0.05 between wavelengths 450-700.

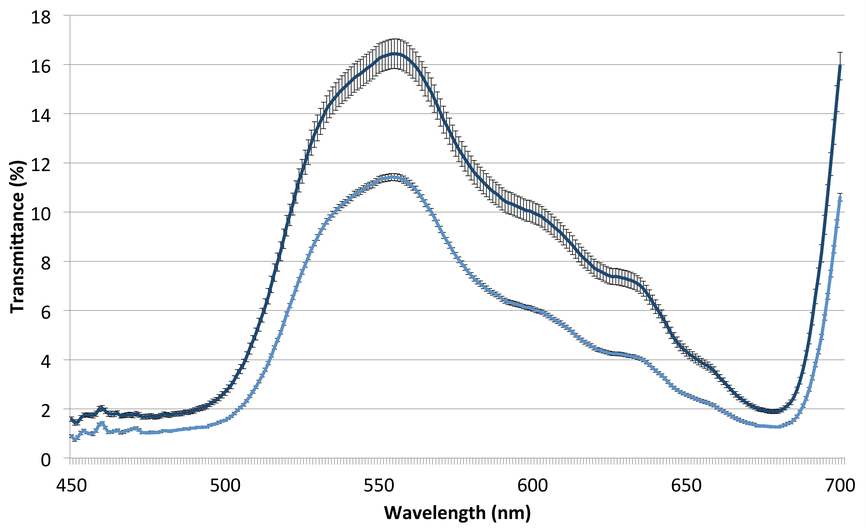


Figure 2. Transmittance of light moving through the leaf from the abaxial surface. The light blue line represents glabrous leaves while the dark blue represents pubescent leaves. 2-Sample T-Test, Error Bars = SEM, p<<0.05 between wavelengths 450-700 nm.

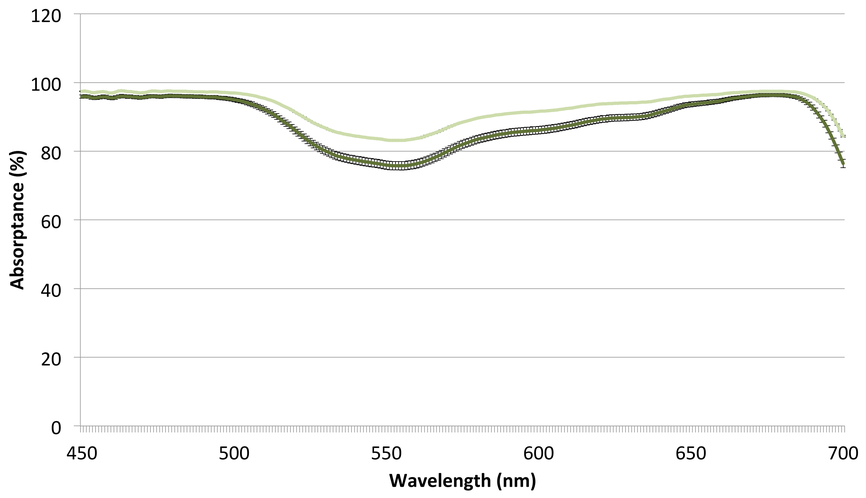


Figure 3. Absorptance of light in the mesophyll of the leaves. The light green line represents glabrous leaves while the dark green line represents pubescent leaves. 2-Sample T-Test, Error Bars = SEM, p<0.05 between wavelengths 513-604 nm and 694-700 nm.

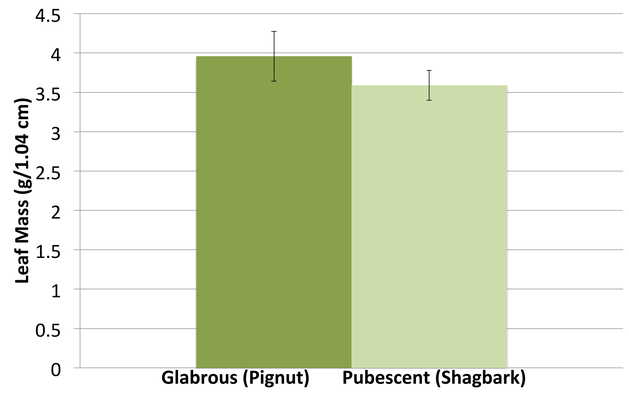


Figure 4. Leaf mass per area. Leaf punches were collected using leaf punches with a circumference of 1.04 cm. 2-Sample T-Test, Error Bars = SEM, p = 0.302.

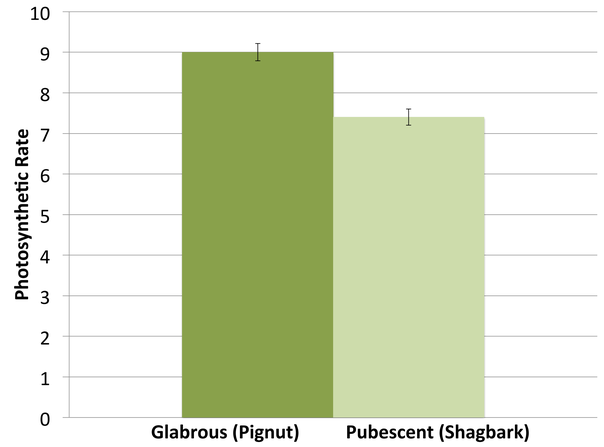


Figure 5. Photosynthetic rates were measured with a licor after the stems were re-cut under water. 2-Sample T-Test, Error Bars = SEM, p = 0.0001.

Discussion

No suggestions that re-reflected light into the leaf enhances photosynthesis because glabrous leaves had higher photosynthetic rates than pubescent leaves.

Species differences potentially contribute to the photosynthetic differences
- They may have different amounts of important enzymes

Pubescence appears to increase re-reflectance of light into the leaf

More transmittance in pubescent leaves was unexpected as we believed trichomes would increase reflectance while reducing transmittance

Absorptance was high in the red and blue spectrum as expected because that is what is used for photosynthesis

Understanding how trichomes work is important when understanding how plants have evolved and how they function in different climates because of their defensive and regulatory qualities

Possible to bio-engineer crops that increase the albedo to help mitigate climate change

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