Role of Abaxial Trichome Density in Regulating Optical Properties and Photosynthesis in *Glycine max*

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Abstract

Trichomes, leaf hair structures, serve plants in a variety ways such as herbivory defense, transmittance of radiation or regulation of temperature. Functions and roles of trichomes are known but the extent of that function based upon trichome morphology and density is not, especially in abaxial (underside) trichomes.

Three isolines of *Glycine max* possessing non-glandular, non-gas exchanging abaxial trichomes were utilized. Two manipulations were conducted; in the first manipulation both the abaxial and adaxial trichomes were removed and in the second just the abaxial trichomes were removed. Abaxial leaf hair density was manipulated using a novel approach via mechanically removing trichomes. Optical properties, gas-exchange, and chlorophyll extraction data were then collected on control and manipulated leaves.

Trichome manipulations reduced density counts 50 to 75% below control leaf levels ($p<0.001$). Photosynthetic rates differed between the control and the two manipulated groups. Leaves with abaxial trichomes removed exhibited a 14.6% reduction in photosynthesis and leaves with abaxial and axial trichomes removed showed a 21.4% reduction in photosynthesis when compared to control leaves. Leaf transmittance in manipulated leaves was observed to be lower than control leaves in the 550-650 nm portion of the electromagnetic spectrum ($p<0.05$). We had hypothesized that transmittance would be higher in shaved leaves compared to unshaved leaves.

Overall, these differences indicate that abaxial trichome density plays a role in leaf carbon uptake and photon transmittance.

Introduction

- Trichomes density is a highly diverse characteristic. Even within some species plants trichome densities can highly pubescent to glabrous (no trichomes).
- Abaxial refers to the lower surface and adaxial refers to the upper surface of the leaf.
- Isolines of the same plant species that vary based upon trichome density provide an excellent tool to quantify the role abaxial trichomes in leaf properties.
- *G. max* (soybeans) were chosen due to the vast array of trichome density in morphology in isolines developed.
- The purpose of this study was to better understand the importance of abaxial trichomes and ultimately provide insight into whether that trichome abaxial densities should (or not) be a characteristic for species grown agriculturally.

Methods

- Three isolines of *G. max* were grown under all under similar growth chamber conditions; T145 (glabrous pubescence) Clark (moderate pubescence) and Mejiro (dense pubescence) isolines were utilized.
- Leaf optical properties (reflectance, transmittance, and absorptance) were assessed on both sides of the leaf using a spectrometer clip coupled with an integrating sphere (Jaz-TR-Spectroclip, Ocean Optics)
- Photosynthetic measurements were taken measuring the flux of CO_2 (LI-6400XT, Li-Cor Biosciences)
- Leaf images for trichome density counts, were taken via light microscopy and using imaging software.
- Trichome removal was conducted mechanically, using a paired approach via coarse cutting with a standard razor blade, followed by close shaving with optical knives (1.2-1.8 mm).
- Damage to the leaf was assessed via pictures and looking for cuticular shaving damage under a light microscope.

Results

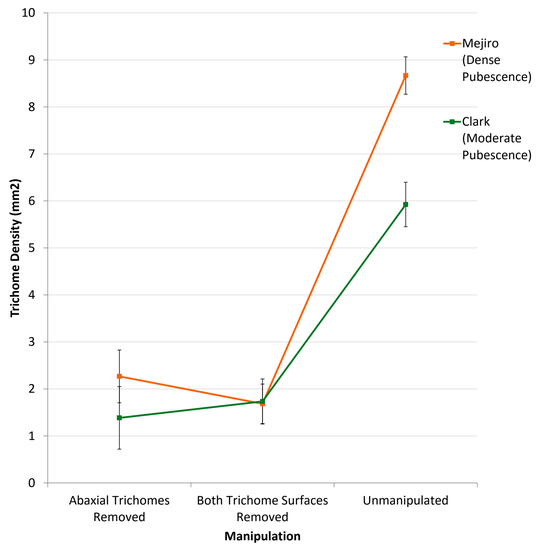

Figure 1: Trichome Density after removal, for the pubescent isolines.The glabrous isoline (not depicted) exhibited little to no presence of tirchomes. Error bars=SEM ($p\approx0.001$,$p\approx0.001$)

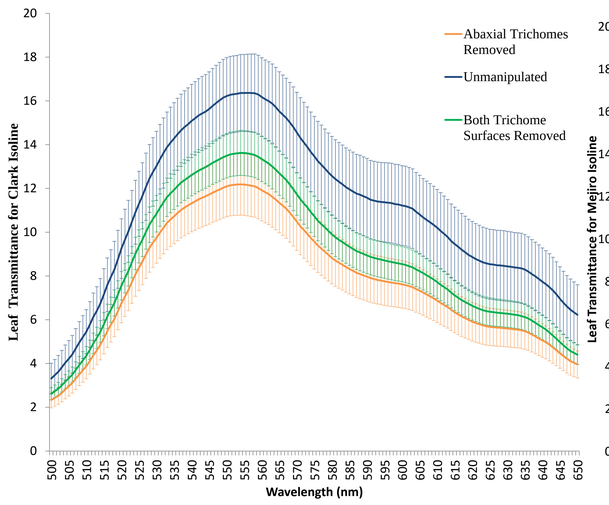

Figure 2: Proportion of light transmitted in the moderately pubescent Clark isoline. Data was compared to the unmanipulated. Error bars=SEM (Paired t-test for abaxial trichome removal , $p=0.0366$)

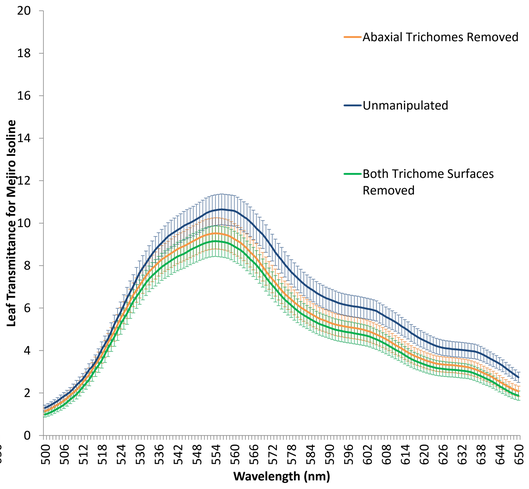

Figure 3: Proportion of light transmitted in the pubescent Mejiro isoline. Error bars=SEM (Paired t-test for both trichome surfaces removed, $p=0.0433$)

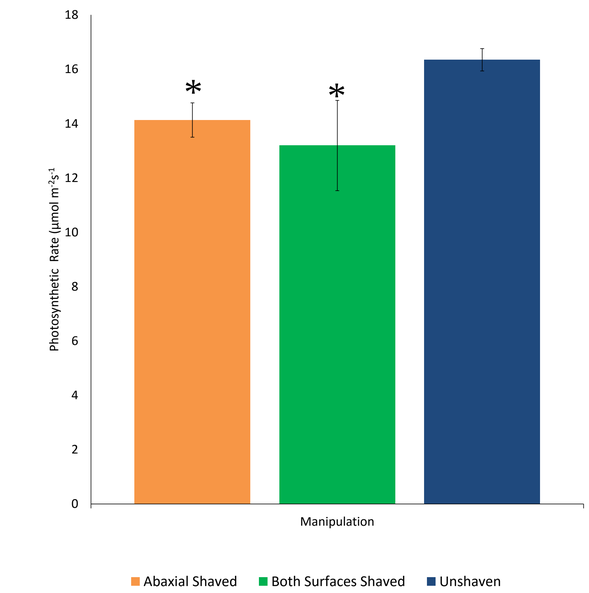

Figure 4: Mean Photosynthesis rate by trichome manipulation. Asterisk indicates signifance from the unmanipulated group. All three isolines are incorporated. Error bars=SEM (ANOVA, $F=9.43$, $Df_{manipulation}=2$, $Df_{error}= 219$, $p\approx0.001$)

Trichome Removal

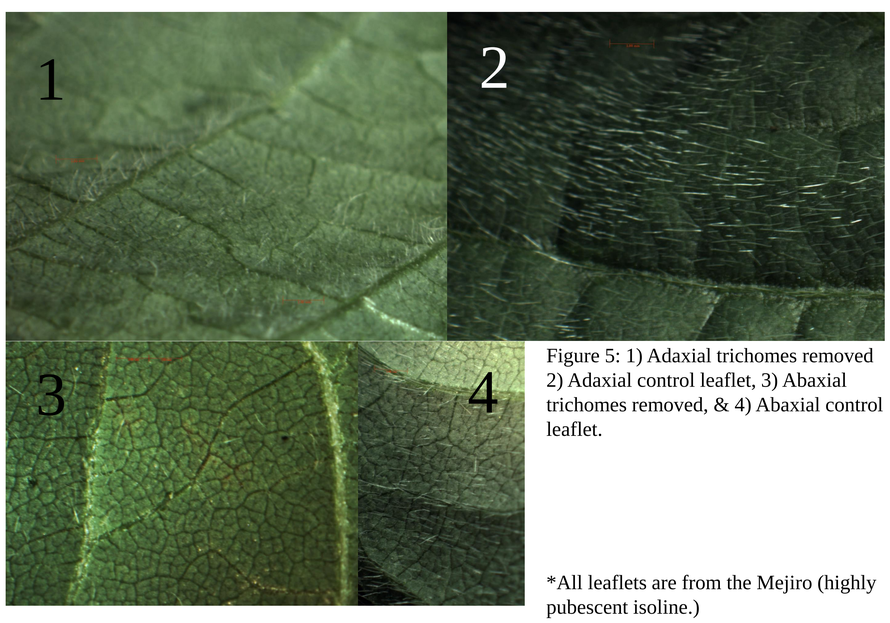

Figure 5: 1) Adaxial trichomes removed 2) Adaxial control leaflet, 3) Abaxial trichomes removed, & 4) Abaxial control leaflet.

*All leaflets are from the Mejiro (highly pubescent isoline.)

Results & Discussion

- Differences in transmittance between the unmanipulated and manipulated groups were present in both pubescent isolines for the 550-650 nm wavelength.
- Clark Isoline: When compared to the unmanipulated group (Figure 2), abaxial trichomes removed ($p=0.0366$) and both trichome surfaces removed ($p=0.0629$) respectively.
- Mejiro Isoline: When Compared to the unmanipulated group (Figure 3), abaxial trichomes removed ($p=0.1033$). Both trichome surfaces removed ($p=0.0433$)
- One hypothesis as an explanation for these differences in transmittance is that the shaving process induced a chemical response of dense photo-capturing compounds to make up for boundary layer loss.
- Photosynthesis was lower in manipulated treatments vs unmanipulated ($p=0.001$). Manipulated groups exhibited similar photosynthetic rates.
- Trichome density varied between isolines in unmanipulated treatments (ANOVA, $p=0.001$), however in manipulated treatments it did not vary ($p=0.657$).
- Optical transmittance of abaxial trichomes appears to be a density dependent property
- Our findings may suggest that abaxial trichomes play a larger role than adaxial trichomes for the plant's respective photosynthetic rate.
- Understanding the trichome density interaction with plant optics and photosynthetic rate, provides a basis for trichome density genetic manipulation, to ultimately increase crop yields under a wider variety of conditions.

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