Evidence for a regulatory linkage between leaf water potential and mesophyll conductance
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Abstract

The transfer conductance of CO₂ from intercellular airspaces to chloroplast stroma, mesophyll conductance (gm), is an important but poorly understood process that is widely thought to be highly responsive to changes in soil water content. In this study we examined the relationship between gm, leaf water status and soil drought. We determined gm by measuring chlorophyll fluorescence in conjunction with leaf gas exchange in well-watered and water-stressed castor bean (Ricinus communis) and tomato (Solanum lycopersicum) plants. Leaf water status was determined by measuring lamina water potential with leaf psychrometers. Both the control and water-stressed groups in castor bean and tomato had similar gm values, with the castor bean showing rates of 0.27 ± 0.02 µmol m⁻² s⁻¹ (well-watered) and 0.32 ± 0.08 µmol m⁻² s⁻¹ (water-stressed; P = 0.57) and tomato exhibiting rates of 0.24 ± 0.02 µmol m⁻² s⁻¹ and 0.22 ± 0.02 µmol m⁻² s⁻¹ respectively (P = 0.55). Likewise, lamina water potential was also similar, with the castor beans having -0.40 ± 0.07 MPa (well-watered) and -0.59 ± 0.12 MPa (water-stressed; P = 0.23) and the tomatoes having -0.41 ± 0.07 MPa and -0.53 ± 0.08 MPa (P = 0.29), despite imposing severe soil drought (mean volumetric water content = 11.9%). Overall, the similarity in gm and water potential observed in well-watered and water-stressed plants indicates a need for further studies to examine the mechanism underlying this response, particularly the role of lamina water potential in regulating gm.

Methods

Tomato (Solanum lycopersicum; n = 10) and castor bean (Ricinus communis; n = 10) plants were grown in 3.8 L and 5 L pots, respectively, in the Kenyon Greenhouse between May 22 – July 18 2013. Plants were well-watered and fertilized until the onset of experimental conditions. Tomato and castor bean plants were randomly assigned to experimental [drought] and control [well-watered] conditions. Droughted plants were water stressed to the desired level, and only a minimal amount of water was given to them in order to maintain that level. Five plants of each species were water stressed (10 – 20 % volumetric water content, VWC), while the rest were kept as control (40 – 60 % VWC). The VWC was measured everyday on each plant using a Field scout TDR 100 soil moisture meter. All measurements were conducted between 0800 – 1600 on consecutive days.

We measured lamina water potential using a leaf psychrometer (Wescor PSYPRO) and automated data logging system. Psychrometers were attached to leaves and allowed to equilibrate for 2 ± h prior to measurements. Leaf gas exchange and chlorophyll fluorescence were determined using the multi-phase flash routine in a portable photosynthesis system (LI-COR 6400). Leaf gas exchange and chlorophyll fluorescence data were used to estimate mesophyll conductance following Warren (2006) (6):

\[ \frac{\pi}{\theta} = \frac{A}{C_\text{p}} + \frac{1}{\text{P} \times (A + \frac{\text{Rd}}{\text{F}})} \]

Where A is photosynthesis, Jα is electron transport rate, and Rd is dark respiration. The value for \( \frac{1}{\text{P}} \) were acquired from Bernacchi et al. (2001) (7).

Conclusions

Findings:
• There was no significant difference in mesophyll conductance and lamina water potential between the control and water stressed groups in both plants studied.
• Both plants studied displayed isohydric characteristics by keeping their water potential constant during severe water stress.

Implications:
• There could be a regulatory mechanism between lamina water potential and mesophyll conductance.
• Due to the isohydric tendencies in both plants, further studies need to be done in plants that do not keep their water potential constant during drought.

Future Studies:
• Anisohydric plants, which exhibit lower leaf water potential throughout the day as water availability decreases, should be tested using this experimental protocol.

Acknowledgements

I would like to thank my mentor Dr. Chris Bickford for his help and guidance throughout the course of this project. I would also like to thank Molly Godsmal as well as Kelsey Dillon for their continuous support in the lab. This project was funded by the Kenyon College Summer Science Scholars Program.

References