Does the Production of Isoprene Affect the Productivity of Poplars?

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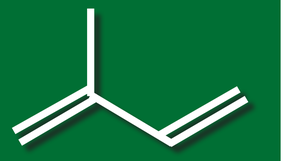
Future Climates

The American Southwest is predicted to become warmer and drier. Research determining how plants and ecosystems will respond to those changes has important implications for the health of ecosystems, carbon and nitrogen cycles, and agriculture.[1] We chose to study poplars due to their importance in the biofuel and paper agroforestry industries.

Isoprene

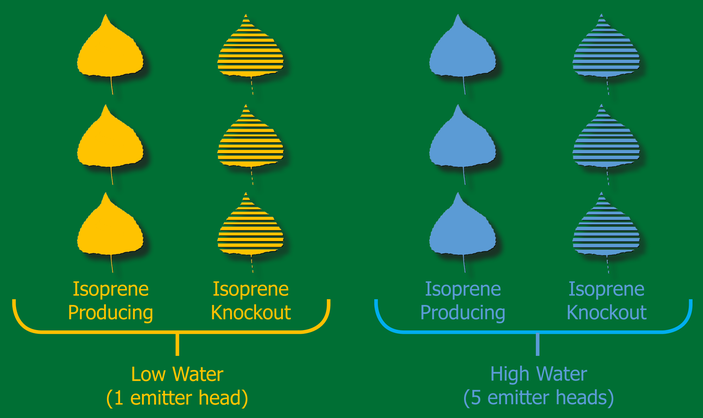
Some poplars produce the compound isoprene, which is thought to help the plant handle heat stress.[2,3] Isoprene is also a greenhouse gas that plays a complex and not fully understood role in atmospheric chemistry.[2] Our study included poplars with the gene to produce isoprene both retained and knocked out.



Common Garden

All poplars studied were planted in a common garden in hopes of reducing environmental variability and to better control treatments.

Poplars were divided into four groups:



Measuring Photosynthesis

A LI-6400XT portable photosynthesis system was used to measure leaf-level photosynthesis in a controlled chamber over a range of temperatures while keeping CO_2 and light levels constant.

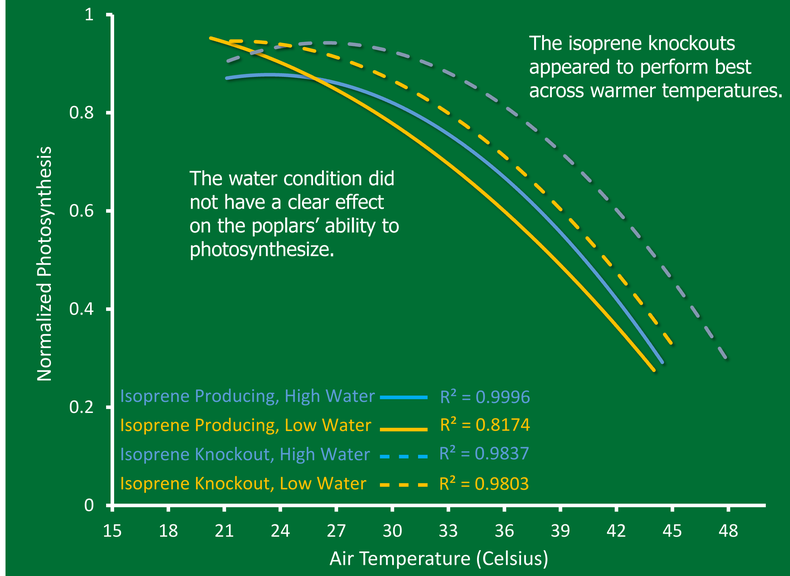
Objective

To determine how isoprene production affects poplars' ability to photosynthesize across different soil moisture and temperature conditions.

Hypothesis

Poplars with the ability to produce isoprene will have higher rates of photosynthesis and reduced thermal sensitivity under drier conditions than those that cannot.

Temperature Curves For Isoprene Producing and Isoprene Knockout Poplars Under High and Low Water Conditions



Three trees per treatment were measured.

Discussion

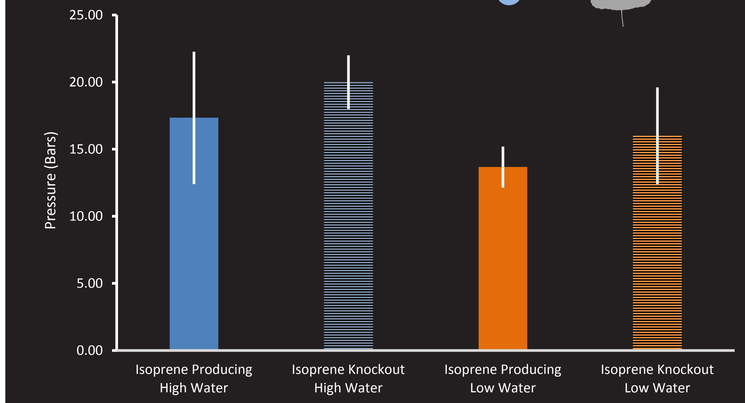
Our results do not support the claim that isoprene production benefits the photosynthesis rate of poplars in either warmer or drier conditions. So why did our hypotheses fail?

Was the source of the issue related to the efficacy of our treatment?

Was there too much variability in our results? Could we have overlooked something?

Were the Poplars Actually Water Stressed?

The more pressure it takes to draw water out of a leaf, the more water stressed it is.

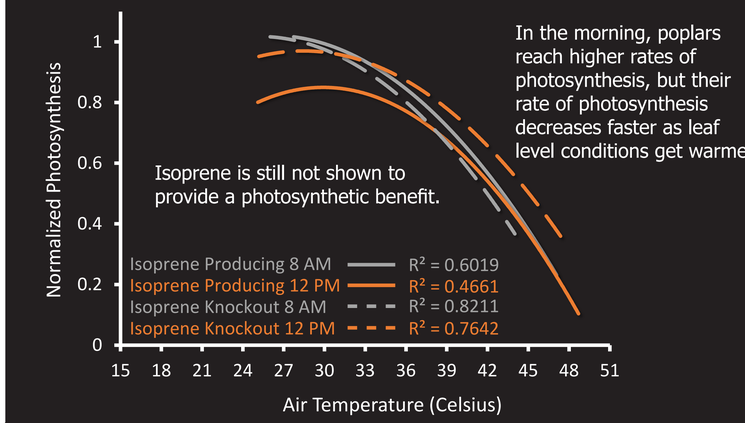


The low and high water treatments did not truly differentiate water stress levels in the poplars. Soil moisture data (not pictured) also supported this claim. A possible explaination could be that poplars use their roots to share water.

Conclusion: The common garden setup is not currently able to produce the water treatments required. Trenching between trees may solve this problem.

Did Time of Day Make a Difference?

Our original data suggested that, even though conditions were controlled at the leaf level, the time of day that the poplar was measured may have affected its rate of photosynthesis, suggesting that whole plant acclimation might play a role. We measured the same trees at two different times to test this hypothesis.



Conclusion: Our results are still not able to replicate the isoprene benefits described in the literature.[2,3] Due to high plant to plant variabilty, a larger sample size may be needed.

Acknowledgements

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Works Cited

1. Barron-Gafford, Greg A., Russell L. Scott, G. D. Jenerette, Erik P. Hamerlynck, and Travis E. Huxman. "Temperature and precipitation controls over leaf- and ecosystem-level CO2 flux along a woody plant encroachment gradient." Global Change Biology 18 (2012): 1389-400. Web. 2 Aug. 2015.

2. Sharkey, Thomas D., Amy E. Wiberley, and Autumn R. Donohue. "Isoprene Emission from Plants: Why and How." Annals of Botany 101 (2008): 5-18. Web. 2 Aug. 2015.

3. Sun, Zhihong, Katja Hüve, Vivian Vislap, and Ülo Niinemets. "Elevated [CO2] magnifies isoprene emissions under heat and improves thermal resistance in hybrid aspen." Journal of Experimental Botany 64.18 (2013): 5509-23. Web. 2 Aug. 2015.

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