Quantifying Water use Efficiency at Leaf and Field Scales for Soybean, Miscanthus and Switchgrass

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BIO

Apurupa Gorthi grew up in the city of Bangalore, India where she earned her bachelor's degree in Chemical Engineering. During this time, she spent her summers working in NGOs and government agencies, truly realizing her dream to work in the line of environmental conservation. In August 2015, she enrolled in Ecological Sciences and Engineering Interdisciplinary Graduate Program at Purdue University and began working in Dr Lisa Welp's lab. Her master's thesis involves quantifying the water use efficiency of common mid-western crops such as soybean, miscanthus and switchgrass using stable carbon isotopes. After graduating, she plans to work in water resource management for agricultural systems. Outside of her research she enjoys playing badminton, loves reading and music.

Ecological Sciences & Engineering Interdisciplinary Graduate Program

Abstract

Understanding the complex relationship between plant carbon assimilation and water loss as a function of various environmental factors is critically important for improving managed agricultural systems. Water use efficiency (WUE) is a measure of the carbon uptake of a plant relative to the water used by the plant. Over the years, it has been described at several spatial and temporal scales depending on methods available for carbon and water flux quantification. One approach for developing crop lines that are well adapted to water limited conditions has been to use leaf-level measurements of carbon isotope ratios to identify those individuals that best conserve water. How this leaf-level water conservation translates to agronomic-scale water has not been thoroughly demonstrated.

This work investigated the water use efficiency of three common mid-western crops, soybean, miscanthus and switchgrass at the Water Quality Field Station (WQFS) from 2010 to 2014. Plant biomass harvested at the end each growing season was analyzed for its carbon isotopic ratio which was used to estimate leaf-level WUE. Further, grain and biomass yields, tile drainage flow and climate data were used to obtain field scale WUE and related metrics.

Results suggest that in soybean, a 2% increase in leaf-scale WUE (transpiration efficiency, µmol CO_2 mmol H_2O^{-1}) during a drought year improved field-scale WUE (agronomic WUE, g kg^{-1}) by 20%. Further, the transpiration efficiency explained 90% of the variability in agronomic WUE over the 5 years, perhaps showing that transpiration efficiency is an effective breeding tool for improved agronomic WUE in soybean. For miscanthus and switchgrass, we observed that miscanthus consistently outperformed switchgrass both in terms of biomass yield and agronomic WUE. Five-year averages of agronomic WUE for miscanthus and switchgrass were 19 kg ha^{-1} mm^{-1} and 7 kg ha^{-1} mm^{-1}. Our results suggested that slight differences within the C_4 pathway may have contributed to differential performance between miscanthus and switchgrass in this study.