Development and Optimization of Unmanned Aerial Vehicle High-Throughput Phenotyping of Field-Grown Switchgrass

Reginald J. Millwood[1]* (rmillwood@utk.edu), Mitra Mazarei[1], Francisco J. Palacios[1], Chandler D. Douglas[1], C. Neal Stewart Jr.[1], and **Gerald A. Tuskan[2]**

[1]University of Tennessee, Knoxville; [2]Center for Bioenergy Innovation, Oak Ridge National Laboratory, Oak Ridge, TN

https://cbi.ornl.gov

Project Goals: The Center for Bioenergy Innovation (CBI) vision is *to accelerate domestication of bioenergy-relevant, non-model plants and microbes to enable high-impact innovations at multiple points in the bioenergy supply chain.* CBI will address strategic barriers to the current bioeconomy in the areas of: 1) high-yielding, robust feedstocks, 2) lower capital and processing costs via consolidated bioprocessing (CBP) to specialty biofuels, and 3) methods to create valuable byproducts from the lignin. CBI will identify and utilize key plant genes for growth, composition and sustainability phenotypes as a means of achieving lower feedstock costs, focusing on poplar and switchgrass. We will convert these feedstocks to specialty biofuels (C4 alcohols and C6 esters) using CBP at high rates, titers and yield in combination with cotreatment or pretreatment. CBI will maximize product value by *in planta* modifications and biological funneling of lignin to value-added chemicals.

Unmanned aerial vehicle (UAV) sensor-based analysis is an emerging and powerful platform for high-throughput plant phenotyping under field conditions. In this study, we explored the potential of UAV-based sensing to measure plant height and area as well as chlorophyll content of field-grown switchgrass. A pilot field experiment was performed in Knoxville, Tennessee from late August to December 2018. A total of 120 lowland (tetraploid) switchgrass GWAS accessions were transplanted in four plots with plant spacing of 1.5 m, 1.75 m, 2.0 m, and 2.25 m. Included within each plot were height reference points of 0 m, 0.5 m, 1.0 m, 1.5 m, and 2.0 m. Plant height and area were determined from UAV flights equipped with a high resolution camera mounted to a 3-axis gimbal. Flights were performed at the end of the growing season while manual measurements for plant height and area were collected for comparison. We found UAV-based plant height measurement correlated strongly with manual measurements ($r = 0.92$), and the same was observed for plant area measurements ($r = 0.94$). In addition, UAV flights equipped with a multispectral camera were performed during the growing season to estimate chlorophyll content. Multispectral images were analyzed through the use of established vegetation indices, and our findings indicated UAV-derived chlorophyll content estimates can be made in switchgrass. However, these data have yet to be "ground-proofed". Owing to a strong positive correlative relationship with chlorophyll, lab-based leaf nitrogen analysis will be performed for confirmation. The UAV-based methods developed here will be incorporated in a large-scale switchgrass GWAS analysis experiment to identify loci associated with high biomass yield and nitrogen use efficiency with subsequent integration into genomic selection models.

The Center for Bioenergy Innovation is a U.S. Department of Energy Bioenergy Research Center supported by the Office of Biological and Environmental Research in the DOE Office of Science.