UAV-based Sustainability Traits Modeling of Field-grown Switchgrass GWAS Population

Yaping Xu*[1,2] (yxu86@utk.edu), Vivek Shrestha[1,2], Cristiano Piasecki[1,2], Benjamin Wolfe[1,2], Lance Hamilton[1,2], Reginald J. Millwood[1,2], Mitra Mazarei[1,2], C. Neal Stewart Jr. [1,2], and **Gerald A. Tuskan**[2]

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

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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 addresses 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 biofuels using CBP with cotreatment at high rates, titers and yield in combination with catalytic upgrading into drop-in hydrocarbon fuel blendstocks.

Unmanned aerial vehicles (UAVs) provide an intermediate scale of spatial and spectral data collection that yields increased accuracy and consistency in data collection for morphological and physiological traits than satellites and expanded flexibility and high-throughput compared to ground-based data collection. In this study, we used UAV-based remote sensing for automated phenotyping of field-grown switchgrass (*Panicum virgatum*), a leading bioenergy feedstock. Using vegetation indices calculated from a UAV-based multispectral camera, statistical models were developed for rust disease caused by *Puccinia novopanici*, leaf chlorophyll, nitrogen, and lignin contents. For the first time, UAV remote sensing technology was used to explore the potentials for multiple traits associated with sustainable production of switchgrass, and one statistical model was developed for each individual trait based on the statistical correlation between vegetation indices and the corresponding trait. Also, for the first time, lignin content was estimated in switchgrass shoots via UAV-based multispectral image analysis and statistical analysis. The UAV-based models were verified by ground-truthing via correlation analysis between the traits measured manually on the ground-based with UAV-based data. Th the normalized difference vegetation index (NDVI) for rust and nitrogen, while NDVI performs better than NDRE for chlorophyll and lignin. Overall, linear models work well for rust disease, chlorophyll and lignin, but for nitrogen, non-linear models outperform linear models. As the first comprehensive study to model switchgrass sustainability traits from UAV-based remote sensing, these results suggest that this methodology can be utilized for switchgrass high-throughput phenotyping in the field.

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