Field experiments of switchgrass GWAS population for increased sustainability: nitrogen-use efficiency and rust disease resistance

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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 specialty biofuels (C4 alcohols, C6 esters and hydrocarbons) using CBP at high rates, titers and yield in combination with cotreatment, pretreatment or catalytic upgrading. CBI will maximize product value by *in planta* modifications and biological funneling of lignin to value-added chemicals.

Switchgrass (*Panicum virgatum* L.) is a perennial C4 grass that is widely considered as a leading candidate for bioenergy production. Its natural traits, including high biomass production, wide adaptation, and low agronomic input requirements, make it a highly desirable bioenergy feedstock. Increased productivity and sustainability of plant feedstocks in bioenergy crops are key factors for biofuel production. Factors affecting switchgrass quality and performance can be broadly attributed to plant genetics and the growing environment, signifying the importance of performing field studies for successful establishment and subsequent sustainability of feedstocks. To this end, a switchgrass genome-wide association study (GWAS) common garden was established in Knoxville, Tennessee containing 330 diverse accessions. A total of four replicated plots (two replicates per low and moderate nitrogen fertility treatment) were established for use in a nitrogen-use efficiency (NUE) study. The switchgrass GWAS field was evaluated manually for various phenotypic and sustainability traits including plant height, dry biomass production, NUE, and progression of rust disease over the growing season. Our results showed wide variation among the GWAS panel. Subsequently, top GWAS accessions representative of high performing genotypes (e.g., with $\geq$ 2.9 m plant height, $\geq$ 4 kg dry biomass/plant, and $\leq$ 35% of rust disease severity) were selected. Furthermore, we developed a drone-based remote sensing modeling approach for switchgrass high-throughput phenotyping and biomass yield in the field. Here, we expanded our study to develop this system for automated assessment of sustainability traits of the field-grown switchgrass. For that, several drone flights over the GWAS field during the growing season were performed. Drone-based analysis was initiated using a multispectral camera and various predictive algorithms to estimate greenness/chlorophyll (an indicator for nitrogen status in plant as well as general health of plant) through photogrammetric image analyses. Our established GWAS field enables identification of superior genotypes and candidate genes associated with high biomass yield and sustainability in long-lived perennial switchgrass.

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