Improving Nitrogen-Use Efficiency of Switchgrass Production: Past, Present, Future

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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 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. And CBI will maximize product value by *in planta* modifications and biological funneling of lignin to value-added chemicals.

Nitrogen (N) is an essential macronutrient for plant growth, although low levels of available-N in most soils limit plant production. Use of synthetic N-fertilizers has largely eliminated this limitation in many agricultural systems, albeit at substantial economic and environmental cost. Moreover, approximately 1-2% of the world's fossil fuel consumption drives industrial fertilizer-N production. Sustained production of plant biomass for biofuels will require constant inputs of N into agricultural systems. To minimize the energy and environmental footprints of biofuel production, we seek plant genotypes that produce high biomass with low fertilizer-N and other chemical inputs. Switchgrass, a highly-productive perennial C_4 grass, is adapted to diverse environments across North America and has been targeted for development as a biofuel feedstock crop. We aim to increase the nitrogen-use efficiency of switchgrass plants and production systems, using a variety of strategies. One strategy is to identify plant genotypes that not only produce large amounts of biomass per unit of fertilizer-N added to the system, but also remobilize a large fraction of the N from shoots to roots during annual plant senescence prior to harvest. This conserves N in the plant for use in the next growth season and reduces the amount of additional N-fertilizer required to sustain production. We found substantial natural variation for N-remobilization efficiency among switchgrass accessions, ranging from 20-61% of shoot-N (Yang et al., *Bioenerg Res* (2009) 2:57–266). Interestingly, some of the most efficient genotypes were also the most productive in terms of biomass, making them ideal parents for breeding programs. Another strategy that we are pursuing is the use of nitrogen-fixing bacteria/endophytes of switchgrass that we plan to engineer to deliver substantial amounts of fixed-N to plants, which would also reduce the need for industrial N-fertilizer.

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