Development and application of novel phenotyping techniques to understand the genetic control of productivity and drought traits in the model C4 grass Setaria

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Genetically tractable model systems closely related to bioenergy grasses need to be developed to drive the crop improvement required for large scale, ecologically sustainable bioenergy production. *Setaria viridis* is an ideal candidate C4 panacoid grass.   The over-arching objectives of this large, collaborative project are to utilize genomic, computational and engineering tools to begin the genetic dissection of drought response in *S. viridis*. This will be achieved through: 1) Quantitative trait and association genetics; 2) novel controlled environment and field phenotyping combined with molecular and chemical profiling; 3) development of metabolic and gene networks; 4) development of transformation technologies*;* 5) reverse genetic testing of candidate genes.

Our ability to cheaply and quickly phenotype large mapping populations of C4 grass crops for complex traits related to productivity and drought tolerance severely limits efforts to understand genotype-to-phenotype associations under field conditions. Here we report the development and application of methods to assess: (1) above-ground biomass production from hemispherical imaging; (2) stomatal patterning from optical tomography; (3) leaf nitrogen status and allometry from hyperspectral reflectance; (4) drought-induced leaf curling from hemispherical imaging; and (5) canopy temperature by infra-red imaging as a proxy for crop water use. We demonstrate that these methods successfully capture the same genotype by environment interactions and reproduce quantitative trait loci analyses as traditional methods that are slower and more expensive. The combination of these advances in phenotyping capability and new knowledge of the genetic architecture of productivity and drought traits creates a research platform that can now be applied to biosystems design of more productive and ecologically sustainable biofuel and bioproduct crops.