Genomics of Energy Sorghum's Water Use Efficiency/Drought Resilience

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Project Goals: The overall goal of this research is to increase the biomass yield and resilience of C4 bioenergy grasses such as energy sorghum by improving water use efficiency, soil water extraction, and drought resilience.

Field data on the growth of energy sorghum leaves, stems and root systems was collected during a ~150-200 day growing season under well watered and water limiting conditions. Energy sorghum root systems grow throughout the long duration vegetative phase accumulating ~10+ Mg/ha of dry root biomass in addition to ~40 Mg of shoot biomass under good growing conditions. The grain sorghum APSIM crop model was modified and used to predict energy sorghum biomass accumulation and soil water extraction dynamics, and to investigate traits that could improve productivity in water limited environments. VPD-limited transpiration, increased leaf angle, and deep rooting systems were found to improve water capture, water use efficiency and resilience. The genetic basis of variation in root system size and morphology in the field was investigated by excavating, washing, and imaging root systems using WINRHIZO. QTL for root system size, root angle, nodal root number, and branching were identified through analysis of RIL populations. Genetic and environmental factors modulating soil water extraction, water use efficiency and water deficit resilience were examined with greater precision using rhizotron-lysimeters filled with field soil in controlled environments. Diverse sorghum genotypes and RIL populations were screened using the rhizotron-lysimeters revealing significant variation in total root system size, root angle, root morphometrics, water use efficiency and root growth responses to water deficit. This system was used to screen RIL populations and to identify QTL that modify a wide range of root traits. A sorghum transcriptome atlas was constructed in collaboration with JGI. Root systems differentially expressed a large number aquaporins among other genes that aid root function. Variation in sorghum root hair biology was analyzed using an ultrasound aeroponic system developed by Marc Libault. Lateral root number increased in response to water deficit in this system, as observed in the field, and in rhizotron-lysimeters. To enhance the microscopic observation and measurement of root hair cells, sorghum root systems were stained with 4% trypan blue solution to maximize contrast. Root hair cell density and morphology was recorded from 5 different locations on the root system using Image J software. Analysis of sorghum RIL populations revealed significant differences in root hair length and growth in response to water deficit. A root hair transcriptome and epigenome resource is being developed in collaboration with JGI.

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