

Transportation Energy Resources from Renewable Agriculture (TERRA)

TERRA projects seek to accelerate the development of sustainable energy crops for the production of renewable transportation fuels from biomass. To accomplish this, the projects uniquely integrate agriculture, information technology, and engineering communities to design and apply new tools for the development of improved varieties of energy sorghum, a crop used to produce biofuel. The TERRA project teams will create novel platforms to enhance methods for crop phenotyping (identifying and measuring the physical characteristics of plants) which are currently time-intensive and imprecise. The new approaches will include automated methods for observing and recording characteristics of plants and advanced algorithms for analyzing data and predicting plant growth potential. The projects will also produce a large public database of sorghum genotypes (the DNA of a plant), enabling the greater community of plant physiologists, bioinformaticians and geneticists to generate breakthroughs beyond TERRA. These innovations will accelerate the annual yield gains of traditional plant breeding and support the discovery of new crop traits that improve water productivity and nutrient use efficiency needed to improve the sustainability of bioenergy crops.

PROJECT DESCRIPTIONS

Clemson University – Clemson, SC

Breeding High Yielding Bioenergy Sorghum for the New Bioenergy Belt - \$6,000,000

Clemson University, along with the Carnegie Mellon Robotics Institute and partners, will phenotype an exhaustive set of international germplasm and plant varieties. Researchers will design and build cutting-edge phenotyping platforms that can rapidly collect visual imagery, hyperspectral imagery and 3-D shape data of test crops multiple times daily. The platforms – ground and aerial – will have the ability to directly contact the plant in order to systematically quantify physical characteristics that were previously measured with labor-intensive, low-throughput methods. The team will use sophisticated cameras and imaging algorithms to develop 3-D models of individual plants and their canopy structure, implement machine-learning techniques to analyze the data gathered and translate this into predictive algorithms for breeding improved biofuel sorghum hybrids.

Donald Danforth Plant Science Center – St. Louis, MO

A Reference Phenotyping System for Energy Sorghum - \$8,000,000

The Donald Danforth Plant Science Center, along with its research partners, will coordinate a national network of test sites in AZ, KS, MO, SC and TX, to provide broad environmental and genetic diversity essential for understanding phenotype behavior. The team will host a state-of-the-art plant phenotyping system, which provides high-resolution evaluation of crops grown under field conditions. In addition, comprehensive genomic analyses will be conducted to create a high-quality reference dataset of energy sorghum's physical characteristics and genetic information. The project will ultimately provide data in community-defined formats that will be made available to researchers in a high-performance computing environment and archived for public use.

Pacific Northwest National Laboratory – Richland, WA

Consortium for Advanced Sorghum Phenomics (CASP) - \$3,300,000

Pacific Northwest National Laboratory (PNNL) and its research partners will utilize novel phenotyping platforms, predictive modeling techniques and image processing tools to generate maps of plant composition and predict plant growth. The project will focus on simulating drought and salinity stresses in order to develop plant varieties that are more resilient to these environmental challenges. PNNL will perform molecular phenotyping to identify breeding markers for these biotic stresses. Meanwhile, Blue River Technologies will develop autonomous phenotyping systems that can create 3-D models of individual plants and construct point-cloud data sets used to produce the plant composition maps. Finally, Chromatin Inc. will advance improved commercial seed cultivars.

Purdue University – West Lafayette, IN

Automated Sorghum Phenotyping and Trait Development Platform - \$6,500,000

Purdue University's team, along with IBM Research and partners, will acquire and utilize data to develop predictive models for plant growth and to design and implement sophisticated methods for identifying genes controlling sorghum performance. The team will create a system that combines data streams from ground-based and mobile platforms for automated phenotyping. Advanced image and signal processing methods will extract phenotypic information to produce predictive models for plant growth and development. The team will also use high-performance computing platforms and prediction algorithms to analyze and identify links between plant characteristics and their underlying genetics. The end goal is to develop a user-friendly system that will enable breeders and other end users to interact with the data and analytics.

Texas A&M AgriLife Research – College Station, TX

Automated Phenotyping System for Genetic Improvement of Energy Crops - \$3,100,000

Texas A&M AgriLife Research (TAMU), along with the National Robotics Engineering Center and partners, will develop an advanced phenotyping system consisting of a suite of sensors mounted on a durable, ground-based, field deployable, mobile robotics platform. The system will employ an extendable, mechanical arm that can penetrate the dense plant canopy to capture images and measurements from above, within and below the crop, yielding previously unattainable sensor data. The team will use TAMU's existing, world-class collection of sorghum varieties and will employ machine vision and learning algorithms to process the data for predictive modeling of plant growth.

University of Illinois at Urbana-Champaign – Champaign, IL

Mobile Energy-Crop Phenotyping Platform (MEPP) - \$3,100,000

The University of Illinois at Urbana-Champaign (UIUC), with its partners Cornell University and Signetron Inc., will develop small-scale, automated ground rovers with the distinct capability to travel within the crops between rows. Phenotyping platforms will measure crop growth via 3-D reconstruction of plants and stands and assess physiological indicators of performance using reflectance and LiDAR (laser light detection and ranging) sensors. The team will also use sophisticated biophysical growth models and DNA-sequencing technologies to develop innovative methods for accelerating improvement of energy sorghum and identifying key genes that control plant performance.