Modeling Energy Sorghum Emissions for the Rainfed United States

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Project Goals: We are using new and existing experimental observations to calibrate and develop biogeochemical models with the explicit goal of improving predictions of biofuels yield and associated greenhouse gas emissions. The experimental data will be used to develop and test new mechanistic knowledge about above- and below-ground plant physiological response to changing environmental conditions (e.g. climate, soil nutrients), management practices (e.g. fertilization, tillage, land type) and varied genotypes. We will also develop the models to represent new genotype plant functional types. For example, as the plants are modified to produce more lipids, this will require new pathways for carbon allocation in the biogeochemical models.

The U.S. Renewable Fuel Standard 2 mandates use of increasing volumes of cellulosic biofuels in the U.S. fuel supply. A substantial body of research has been conducted to design agricultural systems capable of producing large amounts of cellulosic feedstocks, primarily from perennial grasses such as switchgrass (*Panicum virgatum*), energy cane (*Saccharum spp.*), and Miscanthus (*Miscanthus x giganteus*). However, the perennial growth habit of these crops necessitates major changes in equipment and agronomic practice and presents multi-year financial risks to farmers considering their cultivation.

Sorghum (*Sorghum bicolor (L.) Moench*) is a species of heat- and drought-tolerant C4 grass widely cultivated for food, feed and forage. Sorghum can be integrated more readily into traditional crop rotations, and can be managed with conventional equipment. Recent breeding efforts have focused on photoperiod-sensitive varieties that continue vegetative growth until harvested or killed by frost.

The biogeochemical impacts of large-scale biomass sorghum cultivation may differ substantially from those of either corn perennial biomass crops. This work advances understanding of those impacts by first calibrating the DayCent ecosystem model to energy sorghum field data from several years and sites spanning the central and eastern U.S., and then comparing simulated emissions from several thousand sites across the rainfed U.S. under either energy sorghum or conventional corn cultivation. Sorghum emissions averaged 21.2 g CO_2-equivalent per MJ of ethanol, somewhat lower than the corn average of 25.2, but was substantially lower-emitting in several states including Indiana, Kentucky, and Texas. The large fraction of biomass removed during sorghum harvest caused losses of soil organic C on many sites, but also reduced inputs of organic N available for microbial transformation to N_2O. Work is ongoing to assess the potential for no-till management and lower residue collection rates to further improve the emissions profiles of energy sorghum at these sites.

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