Environmental Impacts of Biomass Sorghum Production in the Continental United States

Sagar Gautam[1,2], Umakant Mishra[1,2*] (umishra@anl.gov), Corinne D Scown[2,3,4], Yao Zhang[5]

[1]Environmental Science Division, Argonne National Laboratory, Lemont, IL 60439, United States
[2]Joint BioEnergy Institute, Lawrence Berkeley National Laboratory, Emeryville, CA 94608, United States
[3]Energy Analysis & Environmental Impact Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, United States
[4] Biological Systems and Engineering Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, United States
[5]Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, United States

http://www.jbei.org/

Project goal: Assess biofuel/bioproduct pathway economic and environmental performance at U.S. national scale

Reliable estimates of bioenergy crop yields and their environmental impacts are essential to develop sustainable bioenergy-based land use strategies. In this study, we used the process-based Daily Century (DAYCENT) model with site specific environmental data to simulate Sorghum (*Sorghum bicolor* L. Moench) biomass yield, soil organic carbon (SOC) change, and nitrous oxide emissions across cultivated lands in the continental USA. The simulated rainfed biomass productivity for continental US ranged from 1.4 to 20 Mg ha^{-1} yr^{-1}, with a spatiotemporal average biomass yield of $10^{+0.9}_{-0.9}$ Mg ha^{-1} yr^{-1}, and a coefficient of variation 35%. The spatiotemporal average SOC sequestration and direct nitrous oxide emission rates were simulated as $0.46^{+0.33}_{-0.42}$ Mg CO_2e ha^{-1} yr^{-1} and $0.45^{+0.05}_{-0.03}$ Mg CO_2e ha^{-1} yr^{-1}, respectively. Model predictions were validated using multiyear observed biomass yield data at multiple locations. Compared with field observed data, model predictions of biomass productivity showed a root mean square error of 5.8 Mg ha^{-1} yr^{-1}. Our results suggest 17 million ha cultivated lands in the Southern United States will produce economic Sorghum biomass yield (>10 Mg ha^{-1} yr^{-1}) with net carbon sequestration under rainfed conditions. Cultivated lands of Upper Midwestern states including Iowa, Minnesota, Wisconsin and Michigan showed lower sorghum biomass productivity and net carbon emissions. Our national scale spatially-explicit results are critical for robust lifecycle and technoeconomic analysis of future bioenergy scenarios. Future studies should focus on representing genotypic variations of bioenergy crops and quantifying their total environmental impacts.

Funding statement:

This work conducted by the Joint BioEnergy Institute was supported by the Office of Science, Office of Biological and Environmental Research, of the US Department of Energy under Contract No. DE-AC02-05CH11231.