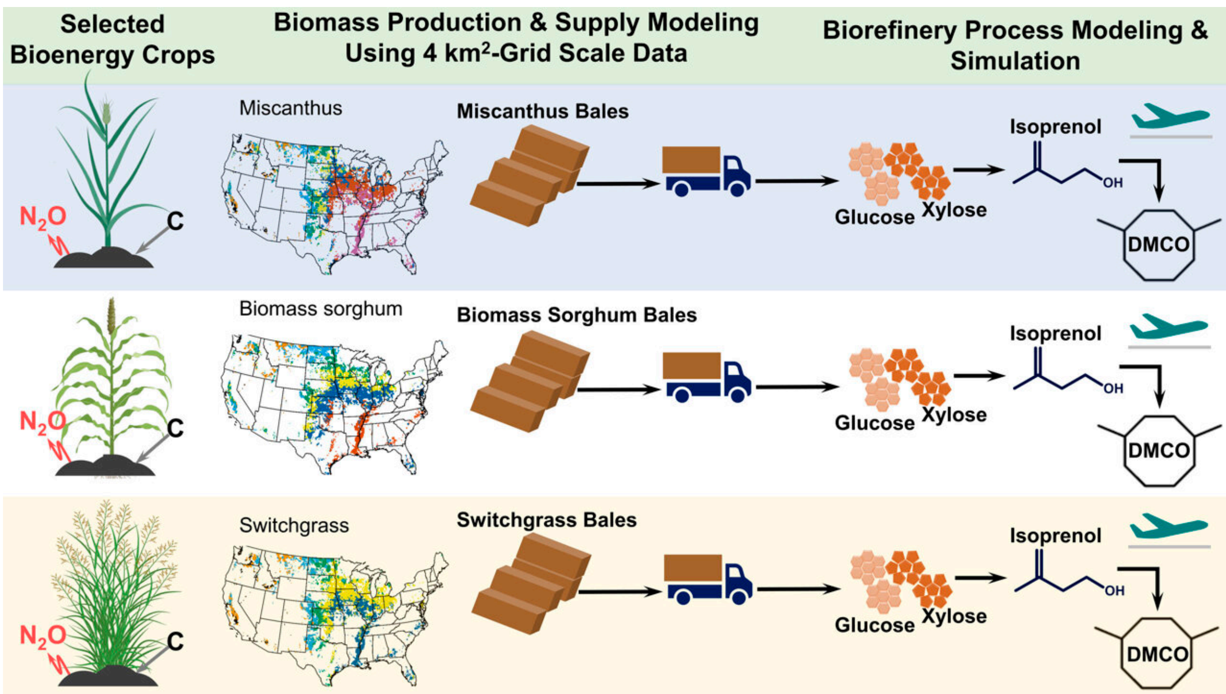
Study identifies performance, economic and environmental tradeoffs involved in turning plants into jet fuel

December 15 2023, by Anya Breitenbach



Overview of field-to-1,4-dimethylcyclooctane (DMCO) production system. DMCO is a cyclic alkane with a volumetric net heat of combustion up to 9.2% higher than Jet A. Credit: *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2312667120

Every year, airplanes crisscrossing U.S. skies burn 23 billion gallons of fuel, leaving contrails and 8% of the nation's transportation-related greenhouse gas (GHG) emissions in their wake. A recent study published in *Proceedings of the National Academy of Sciences* by researchers from the U.S. Department of Energy's (DOE) Lawrence Berkeley National Laboratory (Berkeley Lab) and Sandia National Laboratories reveals which crop-based feedstocks offer the greatest potential for a plentiful, cost-competitive, renewable alternative to petroleum-based jet fuel, while also maximizing atmospheric carbon removal. The scientists conducted the research for the Joint BioEnergy Institute (JBEI), a DOE Bioenergy Research Center managed by Berkeley Lab.

While electric cars are replacing gasoline-powered vehicles on U.S. roads, currently only liquid jet fuels can reliably propel the planes needed to keep hundreds of passengers and tons of cargo in the air. It is estimated that replacing the nation's current fleet of more than 167,000 aircraft with new aviation technology would take 20–30 years, based on the average plane lifespan. Production of sustainable aviation fuel (SAF) from renewable biomass can make it possible to meet the ambitious national goal of cutting the aviation sector's GHG emissions in half by 2050, and it will power existing plane engines.

Biomass crops need to not only produce large quantities of clean-burning, high-performance fuel, but also prove economically feasible for producers, biorefineries, and consumers. In addition, selected feedstocks should maximize carbon accumulation in soils and the efficiency of land use, while minimizing the negative environmental impacts of fertilizer application and water consumption.

There are several candidates to consider as the starting plants for SAF production. The JBEI analysis examines the potential of three high-yielding biomass crops—Miscanthus, sorghum, and switchgrass—to provide feedstocks for commercial-scale production of SAF. Simulation and modeling explored the interplay and tradeoffs between bioenergy, production volume, carbon removal, and fuel prices. Scientists selected the feedstocks for the study because all three can be grown without irrigation on farms across the United States, and can be readily converted into high-performance dimethylcyclooctane jet fuel.

"Identifying the most promising SAF feedstock candidates for a specific location requires evaluation of everything from soil properties to weather patterns, infrastructure, and market factors," said Sagar Gautam of Sandia National Laboratories, lead author of the study.

"Although previous studies have assessed biomass production and impacts at various locations, they have not analyzed the full spectrum of technical, economic, and environmental factors at a national level—until now," said Corinne Scown, the study's senior author, vice president of JBEI's Life-cycle and Economics Division, and deputy for research in the Energy Analysis and Environmental Impacts Division at Berkeley Lab.

The team integrated agroecosystem, techno-economic, and life cycle modeling to identify likely locations for biomass cultivation and estimate how SAF production system costs, life cycle GHG emissions, and the weighting of soil carbon accumulation might impact crop choices. In the near term, Miscanthus appears to be a strong option for SAF, with potential for yields two to three times that of switchgrass and sorghum. Miscanthus similarly could sequester more carbon, result in fewer GHG emissions, and be less expensive to produce—depending on the growing region, the fuel market, and carbon removal incentives.

"We discovered it can be a bit of a seesaw," said Scown. "When we place a high value on soil carbon accumulation and oil prices remain relatively low, Miscanthus looks like the obvious choice. But if oil prices rise more steeply, sorghum and switchgrass become more cost-competitive alternatives."

Through photosynthesis, plants can capture carbon dioxide from the atmosphere and transfer the carbon to the soil through their roots. Scientists continue to study exactly how the carbon interacts with microbes in the soil to promote sequestration. Crops with certain types of deep root systems make it possible to more easily accumulate and store greater quantities of carbon in the soil. This improves soil health and helps combat climate change.

Paying farmers for soil carbon accumulation in addition to the feedstock supply presents extra incentives for growing biomass, but also impacts the cost of production, fuel prices, and market viability.

"Farmers typically choose a crop to cultivate in large part based on whether it's profitable to grow in their region. Carbon removal credits can tip the scales, making it more lucrative to produce a bioenergy crop, and in turn, billions of gallons of clean high-performance jet fuel," said Nawa Baral, co-author and JBEI's scientific lead for life-cycle and technoeconomic analysis.

According to Scown, "If we are thoughtful about how we scale up production and monitor soil carbon impacts, SAF from biomass has the potential to be a win-win for agricultural communities and the climate."

More information: Sagar Gautam et al, Impact of bioenergy feedstock carbon farming on sustainable aviation fuel viability in the United States, *Proceedings of the National Academy of Sciences* (2023). [DOI: 10.1073/pnas.2312667120](https://dx.doi.org/10.1073/pnas.2312667120)

Provided by Lawrence Berkeley National Laboratory

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