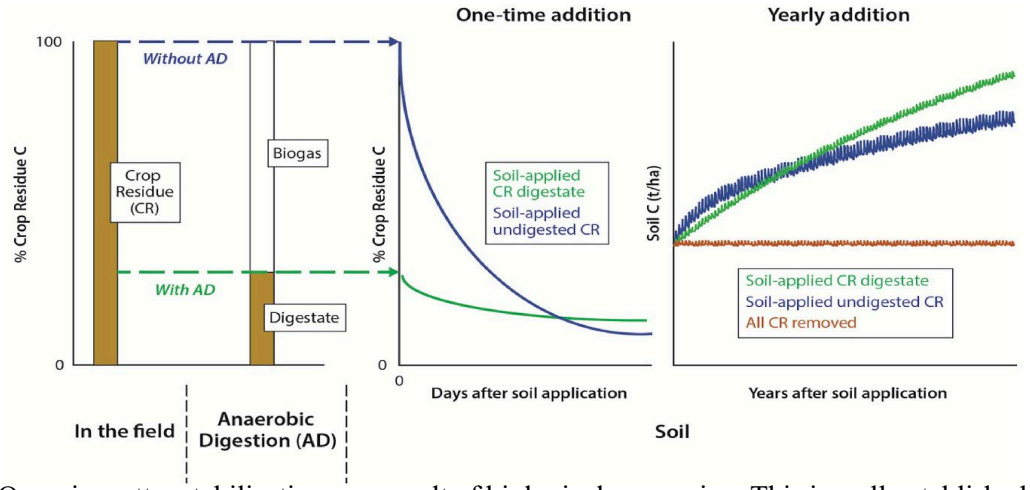
High-Lignin Biorefinery Residues have SOC and N Benefits for Food & Fuel Production

Background

- A longstanding "food vs fuel" debate has limited policy support for biofuels, particularly when considering the scale needed for impactful climate stabilization. This challenge becomes even more pronounced with the need to balance land use between crop production and biofuel feedstock development.

Approach

- A multi-disciplinary team of 13 experts in biofuel production, anaerobic digestion, and soil carbon dynamics conducted an in-depth analysis of two crop residue management strategies: 1) no harvest: crop residues remain in the field, contributing to soil organic carbon (SOC) and nutrient cycling; 2) harvest, process, and return: crop residues are harvested, converted into liquid biofuels, and the high-lignin fermentation byproduct (HLFB) is returned to the soil as an amendment.



Organic matter stabilization as a result of biological processing. This is well-established for anerobic digestion (shown) and hypothesized for liquid biofuel production.

Results

- Long-term SOC levels are expected to be higher when HLFB from liquid cellulosic biofuel processes are returned to the soil, compared to leaving crop residues in the field. We are moderately confident in this expectation.
- The economically optimum rate of nitrogen (N) fertilizer use and N_2O emissions should decrease when HLFB is applied to soil compared to leaving crop residues in the field. We are highly confident in this outcome.
- The per hectare N demand for converting crop residues to liquid biofuels is approximately one-third of the nitrogen demand for crop production – creating an opportunity to use N twice and offering potential cost savings and environmental benefits.

Significance

- These findings suggest a possible "win-win" scenario in the food vs. fuel conflict, where large amounts of liquid biofuel feedstock can be produced from crop residues while simultaneously improving the economics and sustainability of food and feed production.
- The ~100 EJ global crop residue production could provide significant liquid biofuel feedstock, compared to 15 EJ of aviation fuel consumption and 4 EJ of biofuel production globally. Follow-up field studies are proposed to validate the sustainability, energy and biofuel impact of this approach.
- *"Cellulosic biofuels are desperately needed to realize low-carbon goals, but face obstacles related to cost and land. Of great potential significance, this study opens a door to gracefully resolving the land obstacle."* Dan Sperling, Founding Director of the Institute of Transportation Studies, UC Davis.

Lynd, L.R. et al. Environmental Research Letters. (2024). DOI:10.1088/1748-9326/ad601a