BIOENERGY

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The Pyrolysis-Bioenergy-Biochar Pathway to Carbon-Negative Energy

Investigators

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Objective

This work seeks to advance basic understanding of the impacts of biochar on agroecosystems and to assess the technical and economic viability of an integrated pyrolysis-bioenergy biochar industry in the Upper Mississippi River Basin, California and the U.S. Southeast.

Background

Biochar, the condensed aromatic, carbon-rich co-product of biomass pyrolysis, is a soil amendment that is potentially highly effective for sequestering carbon while improving soil productivity (Figure 1).[1] Perennial herbaceous and woody biomass crops grown on marginal lands could simultaneously provide a sustainable supply of feedstock for a pyrolysis-bioenergy biochar industry while performing multiple ecosystem services, including enhanced carbon sequestration, soil-quality improvement, water-quality improvement and increased wildlife habitat, (Figure 2).[2]

The bio-oil and non-condensable gases produced by fast pyrolysis of biomass represent potentially viable sources of liquid transportation fuel, heat, power, bio-asphalt and other products that can offset fossil fuels.[3] The integrated pyrolysis-bioenergy-biochar platform provides multiple pathways toward the production of environmentally, agronomically and economically sustainable carbon-negative energy.[4]

Figure 1: Biochar is applied to research plots at the Armstrong Research and Demonstration Farm near Lewis, Iowa.

The key challenge for scaling up this technology is the identification of economically viable markets for bulk biochar in agriculture. Agronomic research has shown that soil-biochar amendments commonly increase agricultural production on marginal and degraded lands, but may have little or no yield impact on well-managed, high-quality soils, suggesting that the agricultural market for biochar will not be universal. Laboratory experiments have shown that biochar reduces soil bulk density and improves aeration in poorly drained soils. Biochar has also been shown to increase nutrient- and water-holding capacity in sandy, low-organic matter and otherwise degraded soils. Economic value for biochar in production agriculture will likely be found in its strategic use to remediate specific soil problems in specific locations.

Approach

This project will investigate the soil and plant responses to biochar applications through an integrated laboratory research, modeling and field-research validation effort. Regional and global impacts of an integrated pyrolysis-bioenergy-biochar industry on indirect land use and net greenhouse-gas emissions will be studied. Researchers will develop, parameterize and validate a biochar module within the Agricultural Production Systems sIMulator (APSIM)[5] to facilitate investigations of the basic science underlying biochar-soil-climate-crop interactions. Leveraging the APSIM biochar module, the team will quantify the public and private benefits accrued from integrating biochar into pyrolysis-based bioenergy production systems for three regional case studies: the Upper Mississippi River Basin, California and the U.S. Southeast. Techno-economic analysis will be used to assess economic performance and determine the net greenhouse-gas emissions from an integrated pyrolysis-bioenergy-biochar production facility. The researchers also aim to estimate reductions in emissions due to indirect land-use avoidance[7], and to optimize and refine the parameters of the system to maximize economic profitability with the constraint that the fuel is carbon negative. A commercial "go to market" business model that meets the requirement of the private-sector investment community will also be developed.

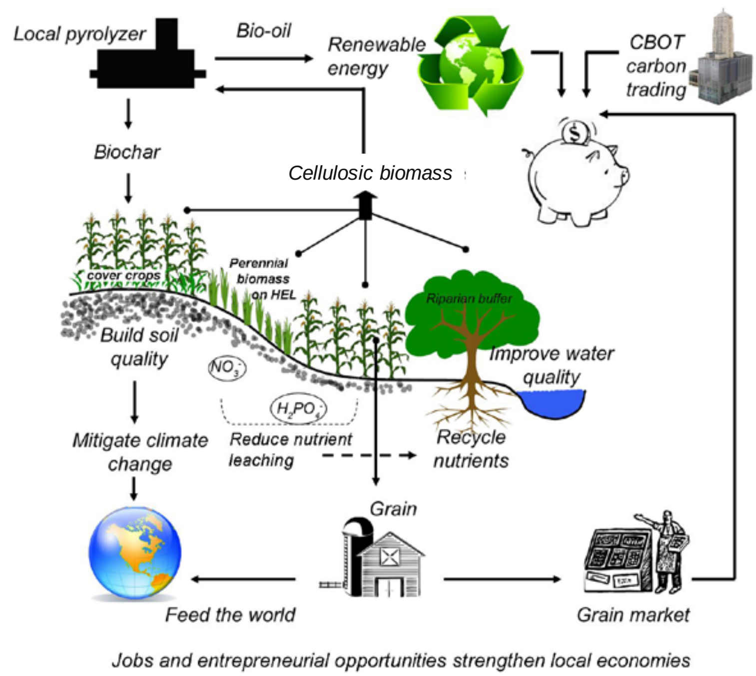

Figure 2: The integrated pyrolysis-bioenergy-biochar platform can provide drop-in liquid transportation fuel or heat/power for industrial processes, while sequestering carbon, enhancing soil quality, increasing agricultural productivity and strengthening rural economies. Strategic placement of perennial biomass crops on highly erodible and otherwise marginal land can also provide economic value and multiple ecosystem services.[4] Figure adapted from Laird et al.[6]

References

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