Effects of co-produced biochar on life cycle greenhouse gas emissions of pyrolysis-derived renewable fuels

Zhichao Wang, Jennifer B. Dunn, Jeongwoo Han and Michael Q. Wang

Biofuels, Bioproducts and Biorefining

Article first published online: 4 OCT 2013 , DOI: 10.1002/bbb.1447
http://onlinelibrary.wiley.com/doi/10.1002/bbb.1447/abstract

Abstract

Background:

Conventional fast pyrolysis is a potential near-term technology for production of liquid renewable transportation fuels from biomass. When applied into soil, biochar, a carbon rich, charcoal-like co-product for fast pyrolysis, has the ability to sequester carbon over the long term, and could generate several unique agricultural effects including suppression of N_2O and CH_4 emissions from fertilized soils, improvements in fertilizer efficiency, and increases in crop yields and soil organic carbon (SOC). Consequently, these effects may influence the life-cycle greenhouse gas (GHG) emissions and energy consumption of fast-pyrolysis-based transportation fuels. In this paper, we examine the influence of biochar agricultural effects on life-cycle GHG emissions of fast and slow pyrolysis systems that use corn stover as a feedstock.

Results:

Overall, life-cycle GHG emissions for fast-pyrolysis-based gasoline are lower when biochar is applied to soil than when it is combusted. 14 g CO_2e/MJ fuel (0.15 kg CO_2e/ kg corn) and 31g CO_2e/MJ fuel (0.36 kg CO_2e/ kg corn) are emitted from these two scenarios, respectively. Carbon abatement (CA) values of fast and slow pyrolysis fuel production systems are comparable, both within the range of 0.8-1.0 kg CO_2e/ kg corn. CA is reduced for an alternative fast pyrolysis system in which the pyrolysis oil is combusted for heat and electricity generation rather than upgraded to a hydrocarbon fuel. In the baseline case with biochar soil application, inclusion of agricultural effects reduces GHG emissions by 2.1 g CO_2e/MJ from 16 g CO_2e/MJ. Biochar carbon content and yield exert the strongest influence on GHG emissions results. Results are also sensitive to biochar's ability to suppress N_2O emissions and increase soil organic carbon, which are subject to high uncertainty.

Conclusions:

The technique used to treat the biochar co-product significantly influences well-to-wheel (WTW) GHG emissions of fast-pyrolysis-based fuels. Aspects of biochar application to soil that most influence LCA results are biochar yield and carbon content. Agricultural effects also influence lifecycle GHG emissions and carbon abatement. Among the agricultural effects considered, reducing uncertainty associated with N_2O suppression and SOC changes would clarify the extent of biochar agricultural effects on life-cycle GHG emissions of pyrolysis fuels.