2014

Comparison of Biofuel Systems (COBS) Project: Biomass energy conversion and energy return on investment analyses for 2012 growing season

Fernando E. Miguez
Iowa State University, femiguez@iastate.edu

Virginia Nichols
Iowa State University

Comparison of Biofuel Systems (COBS) Project: Biomass energy conversion and energy return on investment analyses for 2012 growing season

Abstract
From 2009-2012 the COBS team used a standard method to estimate carbohydrates in the biomass harvested from the biofuel systems in order to determine the cellulosic yields. This project performed the same analysis for 2012 harvested biomass, and further analyzed biomass from 2009-2012 using a method that is less commonly used due to its expense, but is much more accurate.

Keywords
Agronomy, Bioeconomy and energy

Disciplines
Agronomy and Crop Sciences | Oil, Gas, and Energy

LEOPOLD CENTER
FOR SUSTAINABLE AGRICULTURE

Comparison of Biofuel Systems (COBS) Project: Biomass energy conversion and energy return on investment analyses for 2012 growing season

Abstract: From 2009-2012 the COBS team used a standard method to estimate carbohydrates in the biomass harvested from the biofuel systems in order to determine the cellulosic yields. This project performed the same analysis for 2012 harvested biomass, and further analyzed biomass from 2009-2012 using a method that is less commonly used due to its expense, but is much more accurate.

Principal Investigator:

Fernando Miguez

Co-investigator:
Virginia Nichols
Agronomy
Iowa State University

Budget:
$6,468 for year one

Q When comparing prairie biomass and maize stover, does the method of carbohydrate content measurement affect conclusions about crop fuel yields?

ECOLOGY

A Biomass from 2009-2012 was analyzed using a standard method and a very accurate, but expensive method. Results showed that if the goal of the study is to evaluate biomass ethanol conversion potential, the expensive method should be used. If the goal is to compare ethanol yields per unit land area, assuming constant values from literature or utilizing data from the standard method is acceptable.

Background

This project was an integral piece of a larger collaborative project studying tradeoffs associated with potential Midwestern biofuel systems titled Comparison of Biofuel Systems, or COBS. The COBS project was established in 2008, and biomass from 2009-2011 had been analyzed for carbohydrate content (which is used to calculate potential cellulosic ethanol yields) using a standard method of estimation. Iowa suffered an extreme drought in 2012, yet data collection and energy calculations for that year were vital for obtaining a robust data set that represents possible extreme weather years. In 2013 investigators proposed to analyze 2012 biomass for theoretical energy yields using the standard method of carbohydrate content estimation. Additionally, because the COBS project is a long-term study, they planned to analyze biomass from 2009-2012 using a more expensive, but very accurate method in order to evaluate the most resource efficient method for future study years.

The project objectives were to address these questions:

1. Does the standard method for estimating carbohydrate contents of biomass accurately capture differences in carbohydrate contents?
2. How does the method of carbohydrate content estimation affect theoretical ethanol yields per unit land area?

Approach and methods

In order to address objective #1, the COBS team must estimate the amount of fuel (both grain- and cellulosic-derived) each system produces. The cellulosic ethanol yield per unit land area is a function of the amount of biomass harvested, the carbohydrate content of that biomass, and the efficiency with which those carbohydrates are converted to ethanol. At this time, there are no cellulosic ethanol facilities in operation, and therefore no industrial conversion rates for researchers to use. Instead, researchers have studied potential cellulosic ethanol yields by estimating the carbohydrate contents of biomass using laboratory methods and assuming a conversion efficiency. From 2009-2011 the COBS team has utilized a standard method of carbo-

hydrate estimation on the biomass harvested from the systems in order to estimate the cellulosic yields.

The goal of this project was to perform this same analysis for 2012 harvested biomass, as well as analyze biomass from 2009-2011 using a method that is less commonly used due to its cost, but is much more accurate.

Results and discussion

Results showed that the standard method (the sequential filter bag or SFB method) did not accurately capture differences in carbohydrate contents of the prairie biomass and maize stover. The more accurate, but expensive method (known as the National Renewable Energy Laboratory or NREL method) estimated that the unfertilized prairie biomass and maize stover contained equivalent amounts of carbohydrates, while the nitrogen-fertilized prairie biomass had a slightly lower total carbohydrate content.

However, it was discovered that the amount of biomass harvested from a system is the dominant variable dictating the ethanol yield per hectare. This indicates that the choice of method should reflect the goals of the study. If the goal is to compare carbohydrate contents of biomass, the more accurate method should be used. If the goal is to compare ethanol yields per unit land area, using the standard method, or even assuming a constant carbohydrate content, will not severely affect the calculated potential ethanol yields. This finding will relieve the COBS team (as well as other researchers studying cellulosic fuel cropping systems) from performing these time-consuming analyses every year, allowing resources and time to be allocated to other activities.

Conclusions

If the goals of the study are to evaluate and compare biomass conversion potentials of candidate cellulosic feedstocks, it is desirable to use the NREL method. If the purpose of the study lies in comparing land area ethanol yields of corn and prairie systems, utilizing available SFB data or assuming constant conversion rates may be sufficient.

There was a large variation in growing environments between 2009 and 2012. In 2013 biomass yields of the systems fell within the range established during the previous four years. For the COBS study, future years' ethanol yield calculations may be made assuming the four-year average NREL method estimations obtained in this study.

Impact of results

The first generation of cellulosic ethanol plants in Iowa is accepting maize stover as a feedstock. This study indicates prairie biomass (both un- and N-fertilized) exhibits a range of carbohydrate contents comparable to corn stover. Therefore, should a farmer within the harvesting radius of these industries choose to plant prairie plants, it is feasible that these industries could accept prairie biomass as a feedstock with minimal processing changes. This topic requires more research, but the preliminary findings are encouraging.

Education and outreach

Nichols VA, Miguez FE, Jarchow ME, Liebman MZ, Dien BS (2014) Comparison of cellulosic ethanol yields from Midwestern maize and reconstructed tallgrass prairie systems managed for bioenergy. *Bioenergy Research.* DOI 10.1007/s12155-014-9494-9

Nichols VA, Miguez FE (2013) Native Prairie as a Biofuel Feedstock? Potential Cellulosic Harvests and Theoretical Fuel Yields as compared to Corn Stover Systems. Presentation at ISU Graduate Student in Agronomy Annual Research Symposium, Ames

Nichols VA and Miguez FE (2013) Biofuel production stability: effect of drought on ethanol yields from prairie- and corn-based systems. Presentation at the ASABE Annual Meeting, Kansas City, Missouri.

One graduate thesis based on this project was completed: Nichols VA (2014) "Comparison of cellulosic fuel yields and separated soil-surface CO2 fluxes in maize and prairie biofuel cropping systems."

A field day was held for 20 students from Lincoln University (Missouri) as part of a Sustainable Corn Climate Camp in June 2013. The researchers discussed the potential for carbon sequestration of the various biofuel systems being studies at COBS, and demonstrated measurements the COBS team is using to answer these questions.

Leveraged funds

No additional funds were leveraged by this project.

For more information, contact:
Fernando Miguez, Agronomy, 1206 Agronomy Hall, Iowa State University, Ames, Iowa 50011; (515) 294-5980, e-mail femiguez@iastate.edu