cenusa bioenergy

2017

Research Summary: Near-Infrared (NIR) Analysis Provides Efficient Evaluation of Biomass Samples

Near-infrared analysis allows plant breeders and biorefiners to rapidly measure the composition of a biomass sample.

Table of Contents

- Abstract
- Research Purpose
- Research Activities
- What Have we Learned
- Why is this Important
- For More Information
- Contributors to this Summary

Abstract

Researchers at the United States Department of Agriculture's Agricultural Research Service (USDA-ARS) have found that genetic, management, storage, and environmental factors affect the chemical composition of switchgrass samples. Using a database of 100 samples, they are constructing a robust near-infrared (NIR) calibration for switchgrass that can be used, ultimately, for other warm-season perennial grasses.

The initial NIR calibration for switchgrass appears to be accurate for measuring 23 plant properties, including cell wall components and soluble sugars. (1) The final NIR calibration will be used for breeding improved bioenergy crop lines and will eventually be released to biorefiners to be used commercially in both thermochemical and biochemical conversion processes.

USDA This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

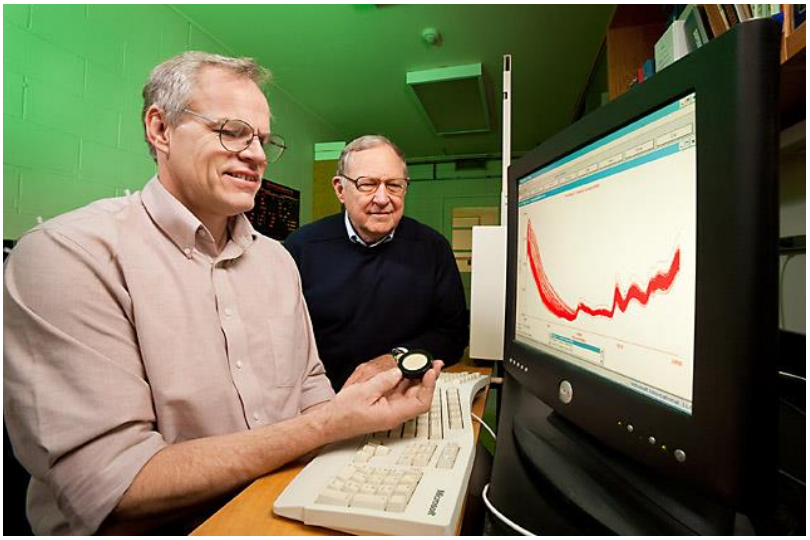

Figure 1. ARS scientists Ken Vogel (geneticist, background) and Steven Masterson (technician) examine near-infrared reflectance spectral profiles of switchgrass samples for 20 components.

Research Purpose

Knowledge of biomass composition is critical in order to breed improved bioenergy crops. This knowledge also enables biorefiners to rate the quality of biomass delivered to their factory gates, which bears directly on the feedstock's performance and conversion efficiency in the processing facility.

Laborious wet chemistry methods precisely measure various carbohydrates, lignin, waxes, and other chemical properties. However, analysis time per sample is slow—on the order of weeks—and therefore impractical for characterizing thousands of samples for breeding purposes or for rating delivered biomass while a delivery truck waits to unload. The solution is to scan the samples with NIR, which analyzes a sample in seconds in a simple and nondestructive way. Research Activities

Research Activities

By adapting wet chemistry methods, Bruce Dien and Victoria Nguyen of the USDA-ARS analyzed the chemical composition of more than 100 samples that were supplied by their colleagues Robert Mitchell, Michael Casler, and Kenneth Vogel. Akwasi Boateng of the USDA-ARS is processing an identical sample set for pyrolysis conversion to biofuel. Vogel and Boateng are also analyzing the samples for elemental constituents and forage quality measurements.

The data set, which builds upon previous research by Hans Jung, former USDA-ARS researcher, will eventually be analyzed to correlate chemical composition with pyrolysis

USDA This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

results and to construct an NIR calibration by CenUSA Co-Project Directors Robert Mitchell and Michael Casler.

What We Have Learned

Switchgrass composition varies widely, depending on genetics, management, and environmental factors. Knowledge of composition is important because it directly affects product conversion yields and the reaction conditions for optimal processing. NIR offers an accurate measurement of biomass samples within minutes.

Why Is This Important?

A rapid and inexpensive method for analyzing chemical composition of switchgrass and other warm-season grasses will enable effective plant breeding of improved bioenergy crop lines. It will also help commercial biorefiners to efficiently and accurately grade delivered biomass right at the factory gate.

Additional Notes

Plant properties measured by dietary fiber method:

- Waxes and lipids (hexane extractables)
- Soluble sugars: Sucrose, Glucose and Fructose
- Storage carbohydrates: Starch and Fructans
- Cell wall components: Cellulose, Xylan, Arabinan, Galactan, Mannan, Uronic Acids (e.g., Pectin), Klason Lignin, Acid Soluble Lignin, p-coumarate esters, esterified ferulates, etherified ferulates
- Calculated: Theoretical ethanol
- Others: Ash, Minerals, and Detergent fiber components (NDF, ADF, and ADL.)

(1) Vogel, Kenneth P., Bruce S. Dien, Hans G. Jung, Michael D. Casler, Steven D. Masterson & Robert B. Mitchell. 2011.Quantifying actual and theoretical ethanol yields for switchgrass strains using NIRS analyses. BioEnergy Research 4 (2): 96-110.

For More Information

CenUSA Project Resources – information on the opportunities and challenges in developing a sustainable system for the thermochemical production of biofuels from perennial grasses grown on land marginal for row crop production.
www.cenusa.iastate.edu

USDA This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

Contact **Dr. Bruce Dien**, CenUSA Collaborator and Lead Scientist, Bioenergy Research Unit, ARS, Peoria, IL Bruce.Dien@ars.usda.gov, 309-681-6270

- Boateng, A. A., K. B. Hicks & K. P. Vogel. Pyrolysis of switchgrass (Panicum virgatum) harvested at several stages of maturity. 2006. Journal of Analytical and Applied Pyrolysis,75 (2) 55-64.
- Crop Management Impacts Biofuel Quality: Influence of Switchgrass Harvest Time on Yield, Nitrogen and Ash of Fast Pyrolysis Products; Danielle M. Wilson, Dustin L. Dalluge, Marjorie Rover, Emily A. Heaton & Robert C. Brown, BioEnergy Research, July 2012.
- Managing and Enhancing Switchgrass as a Biofuel Feedstock, Robert Mitchell, Kenneth Vogel & Gautam Sarath, USDA-ARS

. . . and justice for all

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Many materials can be made available in alternative formats for ADA clients. To file a complaint of discrimination, write USDA, Office of Civil Rights, Room 326-W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call 202-720-5964.

Iowa State University Extension programs are available to all without regard to race, color, age, religion, national origin, sexual orientation, gender identity, genetic information, sex, marital status, disability, or status as a U.S. veteran. Inquiries can be directed to the Director of Equal Opportunity and Compliance, 3280 Beardshear Hall, (515) 294-7612. Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.

USDA This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

www.cenusa.iastate.edu