Predicting Switchgrass Ethanol Yields

The truck pulls up to the ethanol biorefinery with a load of switchgrass. A technician greets the driver, inspects the load, and samples several switchgrass bales on the truck. The samples are brought to the nearby office lab and quickly analyzed for biomass composition and the maximum and expected ethanol yields per ton of switchgrass. This information enables the biorefinery to pay switchgrass producers for both the tonnage and the quality of their crop. A biorefinery could even reject a subpar shipment of switchgrass before the truck is ever unloaded.

That future has been made possible by a team of Agricultural Research Service scientists, including Ken Vogel, Rob Mitchell, and Steve Masterson at Lincoln, Nebraska; Hans Jung at St. Paul, Minnesota; Bruce Dien at Peoria, Illinois; and Michael Casler at Madison, Wisconsin. They developed the use of near-infrared sensing (NIRS) to measure 20 components in switchgrass biomass that determine its potential value to biorefiners. These components include cell wall sugars, soluble sugars, and lignin.

With this information, 13 traits can be determined, such as the total theoretical or maximum ethanol yield as well as the efficiency of the conversion from sugars to ethanol. Measuring cell wall sugars can also be used to calculate the maximum yield for fermentation to other biofuels and chemicals.

This is the first use of NIRS to predict maximum and actual ethanol yields of grasses from a basic conversion process. This capability already exists for corn grain using NIRS. "Corn is the easiest crop to grade for ethanol yield," says Vogel, who is in the ARS Grain, Forage and Bioenergy Research Unit in Lincoln.

Predictions of actual ethanol yields were based on hexoses, or six-carbon sugars, present within the plant cell wall and as soluble sugars. Since additional ethanol could be produced from pentoses, or five-carbon sugars, as conversion technology improves, the NIRS method can be used to estimate what the total potential yield of ethanol or other biofuels would be if all sugars in the plant were converted.

The scientists used NIRS to test switchgrass varieties and experimental lines adapted to the Midwest and found significant differences for actual and potential ethanol yield per ton and per acre. The lowland variety Kanlow had the highest crop yield but the lowest ethanol conversion efficiency, resulting in the lowest predicted ethanol yields per ton—but the largest ethanol yields per acre. An experimental upland strain, NE 2229, had the highest predicted ethanol yields per ton, with the third highest crop yield.

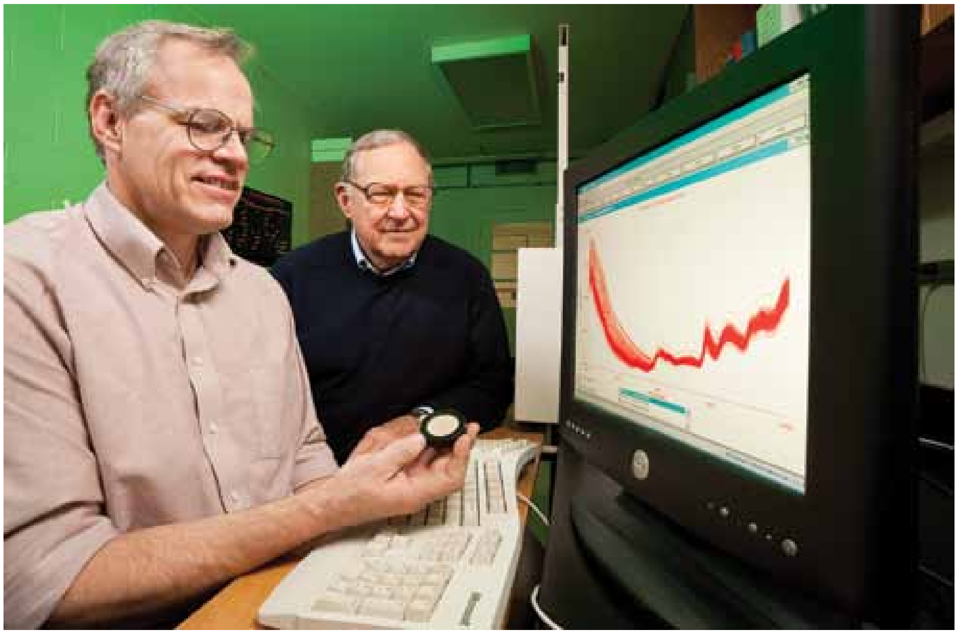
Vogel says, "The importance of this study is that we've shown it's feasible to use NIRS to estimate ethanol yields of switchgrass at about $5 a sample, instead of $300 to $2,000 a sample using conventional analytical methods. The low price makes the method available for use in research by breeders, agronomists, and biorefineries."

The calibrations developed in this study—and improved future versions—can be used in all aspects of plant research, including basic genetics, harvest, and storage for a variety of perennial grasses, including those used for forage as well as those used for ethanol production. Casler says, "The NIRS equations are already being used for developing new cultivars in the ARS breeding programs in Nebraska and Wisconsin."

"This method can also be used to develop management practices that can result in improved ethanol yields per acre," Vogel says.—By **Don Comis,** ARS.

This research supports the USDA priority of developing new sources of bioenergy and is part of Pasture, Forage, and Rangeland Systems (#215) and Bioenergy (#213), two ARS national programs described at www.nps.ars.usda.gov.

Kenneth P. Vogel is in the USDA-ARS Forage and Bioenergy Research Unit, 137 Keim Hall, East Campus, University of Nebraska, Lincoln, NE 68583; (402) 472-1564, ken.vogel@ars.usda.gov.



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Biological technician Steven Masterson (left) and geneticist Ken Vogel examine the near-infrared reflectance spectral profiles of switchgrass samples collected from switchgrass bales. The near-infrared sensing calibration equations developed for determining switchgrass composition and ethanol conversion are being used to determine the effects of switchgrass bale storage conditions on ethanol conversion. Masterson is holding a sample ring with the ground switchgrass sample.