We REAP What We SOW

Examining Costs/Benefits of Using Corn Stover for Bioenergy

DOUG WILSON (K7188-18)

In February 2006, President Bush launched an ambitious plan called the "Advanced Energy Initiative." Its aim is to reduce America's crude oil imports from the Middle East by 75 percent by the year 2025. One key milestone calls for displacing 15 percent of our gasoline with 35 billion gallons of renewable and alternative fuels, such as ethanol, by 2017.

Corn, America's most widely grown crop, currently plays a central role in supplying the starch-derived sugars used to make ethanol. Bioenergy researchers are also exploring ways to use corn's cellulosic residue, called "stover," as a feedstock for ethanol production.

Stover consists of the stalks, leaves, and cobs that remain in the field after grain harvest. Left in place to decay, stover builds soil organic matter and reduces erosion by protecting soil during strong winds or intense rainfall. It also helps sequester carbon in the soil. And now it's being eyed as an abundant feedstock for ethanol production.

These competing uses for stover create a quandary.

Wally Wilhelm, an Agricultural Research Service plant physiologist in Lincoln, Nebraska, is leading a team to help determine how much corn stover can be harvested without increasing erosion or hampering the soil's ability to build organic matter and sequester carbon. Wilhelm is in ARS's Agroecosystem Management Research Unit.

REAP Takes a Long View

In June 2006, Wilhelm became lead scientist for the Renewable Energy Assessment Project (REAP), a 5-year multilocation research project to obtain what he calls "ground-truth" data. Of particular interest to the REAP team is determining where, when, and how much stover can be harvested without harming the soil.

"Growers, ethanol producers, and action agencies need information and guidelines based on current, geographic-specific yield potentials and production practices," Wilhelm says.

A project of this magnitude requires the expertise and resources of a broad range of experts. REAP collaborators include state universities and the Department of Energy's Idaho National Laboratory as well as ARS scientists at nine locations around the country:

- John M. Baker, Rodney Venterea, and Tyson E. Ochsner, Soil and Water Management Research Unit, St. Paul, Minnesota. The team is experimenting with winter cover crops and living mulches such as kura clover, which is interseeded with corn, as possible ways to harvest biomass without jeopardizing soil health or productivity.
- Jane M.F. Johnson and Don Reicosky, North Central Soil Conservation Research Laboratory, Morris, Minnesota. The duo established experimental plots and on-farm trials to find a balance between stover used for protecting the soil and stover used for bioenergy. They're measuring carbon in the soil and the amount of carbon dioxide and other greenhouse gases returned to the air. They also want to know how much stover needs to stay in the field with different tillage methods.
- Wally Wilhelm and Gary E. Varvel, Soil and Water Conservation Research

Bales of corn stover collected from a REAP experiment near York, Nebraska. Stover is often left in place to protect soil, but it also has potential as a feedstock for cellulosic ethanol production.

WALLY WILHELM (D816-1)

Unit, Lincoln, Nebraska. In collaboration with two brothers who operate a family farm, the ARS scientists are helping conduct studies on cropland with high-, medium-, and low-productivity soils. Wilhelm says the study, which covers 100 acres of corn and involves the use of field-scale equipment, will provide a real-world opportunity to examine stover harvesting's effect on organic matter, grain yield, and carbon sequestration in the western Corn Belt.

■ Shannon L. Osborne, North Central Agricultural Research Laboratory, Brookings, South Dakota. Osborne leads a long-term study initially designed to examine the impact of removing corn stover on soil quality. In 2006, cover crops were incorporated into the experiment to determine whether maintaining a continuous cover will replace some of the soil carbon that's lost when residue is harvested for biofuel production.

■ Douglas L. Karlen, Soil and Water Quality Research Unit, and Cynthia A. Cambardella, Agricultural Land and Watershed Management Research Unit, National Soil Tilth Laboratory, Ames, Iowa. Their studies encompass field evaluations of how much stover can be harvested using a systems approach that includes either chisel or no-tillage practices, cover crops, and increased plant populations and fertilizer applications. They're also examining the formation and decomposition of organic soil carbon; factors affecting crop-residue decomposition, such as microbial activity; and the impact of returning charcoal to the soil. Charcoal is a byproduct of pyrolysis, an alternative to fermentation for converting biomass into fuel.

■ Hero T. Gollany, Columbia Plateau Conservation Research Center, Pendleton, Oregon. Gollany's studies to predict carbon sequestration in agricultural soils, using the model CQESTR, are helping develop a formula, or algorithm, to guide sustainable residue removal. The computer model simulates yearly losses or gains of organic carbon based on different soil-management practices such as no-till.

■ Ronald Follett, Soil Plant Nutrient Research Unit, Fort Collins, Colorado. Follett is leading part of a long-term study designed to develop soil carbon storage information and to examine the potential for biofuel crops (corn, switchgrass) to sequester carbon under improved management (plant type, nitrogen-fertility, and no-till). Baseline samples were collected in 1998. Soil sampling is at 3-year intervals through at least 2007.

■ Francisco J. Arriaga and Jason S. Bergtold, National Soil Dynamics Laboratory, Auburn, Alabama. Cotton production under conservation tillage in the Southeast often uses cover crops, such as rye and wheat, to provide erosion and weed control during the winter months. The scientists are studying the potential of harvesting the winter cover biomass in spring, before cash-crop planting, and its effects on crop productivity and profitability.

■ Diane E. Stott, National Soil Erosion Research Laboratory, West Lafayette, Indiana. Stott is seeking to better understand and measure the amount and form of soil carbon and nitrogen in fields where stover has been harvested. Stott and ARS colleague Dennis Flanagan are also using water- and wind-erosion models to determine the impact of various levels of stover harvest on soil loss by runoff or wind.

Wilhelm says the stover-management guidelines being developed under REAP are one piece of a larger bioenergy puzzle. Elsewhere, for example, research is under way to develop powerful enzymes to free sugars from cellulose and to streamline the ethanol-production process. (See the April 2007 issue of *Agricultural Research.*)

Ratcheting up solar-radiation use efficiency may also increase biomass for ethanol uses. Such relatively simple practices as optimum planting dates, proper row-spacing schemes, green manures, and appropriate nitrogen and water management will make initial improvements.

Later advances will include optimizing canopy structure, leaf arrangement, and placement.

"We hope molecular engineering technologies will eventually provide plants with enhanced photosynthetic capacity to keep us moving up the radiation-use efficiency scale and provide sufficient biomass to satisfy the soil's need for carbon and the nation's needs for fuel," says Wilhelm.—By **Jan Suszkiw,** ARS.

This research is part of Soil Resource Management (#202), Global Change (#204), and Bioenergy and Energy Alternatives (#307), three ARS national programs described on the World Wide Web at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Jan Suszkiw, USDA-ARS Information Staff, 5601 Sunnyside Ave., Rm. 1-2220C, Beltsville, MD 20705-2350; phone (301) 504-1630, fax (301) 504-1486, e-mail jan.suszkiw@ars.usda.gov. ✷

TYSON OCHSNER (D819-1)

ARS technician Todd Schumacher installs soil moisture monitoring equipment in a kura clover living mulch experiment at a University of Wisconsin research farm in Arlington, Wisconsin. Row locations of recently planted no-till corn are evident from the effects of band-applied herbicide directly over the rows.