

BioCentury Research Farm Update

RFR-A15114

Andrew Suby, Manager

Introduction

The BioCentury Research Farm (BCRF) experienced a change of leadership in 2015 when Larry Johnson retired as director of the farm in April and Kevin Keener succeeded him as director in November.

The BCRF had a diversity of users in 2015. Iowa State University (ISU) faculty and staff from the Departments of Agricultural and Biosystems Engineering (ABE); Agronomy; Biochemistry; Civil, Construction, and Environmental Engineering; and Food Science and Human Nutrition (FSHN), as well as the Bioeconomy Institute (BEI), Center for Crops Utilization Research (CCUR), College of Agriculture and Life Sciences, and Extension and Outreach conducted research, teaching, and/or outreach at the BCRF. Private industry users of the BCRF included AGCO, Avello Bioenergy, Deere & Company, DuPont Cellulosic Ethanol, Phillips 66, and Virent, Inc. By the end of 2015, the BCRF had more than 96 full- and part-time users with projects in all available space.

Research, Upgrades, and Equipment

A great deal of research project activity occurred in the following areas:

- Algae research and production methods
- Biomass feedstock logistics research
- Biomass feedstock preparation
- Biomass conversion to value-added products
- Infrastructure and equipment upgrades
- Thermochemical research that included biomass gasification, pyrolysis, and solvent liquefaction processes

Algae. Various production systems located in the BCRF Algae Facility are being used to grow algae including flat panel bioreactors, two raceway pond systems, a novel revolving algal biofilm (RAB) system, and various lab-scale reactors. The major focus for these algal growth systems is to remove nutrients (nitrogen and phosphorus) and toxic metals from municipal and industrial wastewater. A new mobile pilot-scale RAB system was developed in 2015 to treat wastewater on site at municipalities and industrial processors. Additionally, newer belt designs were added in 2015. The researchers led by Zhiyou Wen, FSHN Department, can produce 1.3 to 4.5 kg of dried algae biomass/week.

The lipid, protein, carbohydrate, and ash levels in the algae are analyzed, and fatty acid and amino acid profiles are measured.

The diverse algae species grown in the facility are suited for different end uses. Algae with high lipid levels are good for producing biodiesel, and algae with high protein levels and good amino acid profiles are good livestock feed. Algae biomass grown on wastewater is being studied as organic fertilizer.

Biochemical. Work slowed in this area in 2015 due to an economic downturn in the industry. Bench-scale projects continued on campus and there is potential for scaling up at BCRF in 2016.

Biomass feedstock collection. Multiple projects continued in this area in 2015 with the most notable ones related to the DuPont Cellulosic Ethanol (DCE) and POET-DSM Advanced Biofuels research led by Matt Darr and Stuart Birrell, ABE Department.

For the DCE project, work continued in the area of corn stover bale collection. This effort included a combination of the ISU stover harvest and DCE harvest teams. The BCRF received numerous bales for observation, stack testing, and ash and moisture content sampling. Over 11,000 bale samples were processed during the 2015 harvest. This is a typical number of samples processed.

The POET-DSM plant began production in 2014 and the new DCE plant had its grand opening October 30, 2015. The DCE plant currently is being commissioned with a projected date of operation of June 2016.

Agricultural product development and research support for several major agricultural equipment manufacturers such as AGCO, John Deere, New Holland Agriculture, and Vermeer continued in 2015. In particular, New Holland Agriculture continued to provide ISU with equipment for quantifying the efficiency of harvesting biomass crops.

One such project was to understand field-scale switchgrass production. The project harvested and baled 18 acres of switchgrass and was led by Emily Heaton and Nic Boersma, ISU agronomy department. The work was funded by USDA and the North Central Sun Grant Initiative.

The switchgrass bales will be used at ISU research farms and in dairy bedding trials in collaboration with Floyd Valley Biomass LLC and Maassen Dairy.

The BCRF also helped plant *Miscanthus* rhizomes with a semi-automated planter at three locations in Iowa. This project, the Long-term Assessment of *Miscanthus* Productivity and Sustainability (LAMPS), is designed to answer several questions about *Miscanthus × giganteus* production. The overarching goal for LAMPS is to answer the

questions farmers are asking about *Miscanthus*, especially those concerning fertility rates and quantifying yields using commercial harvest equipment.

LAMPS has several partners and sponsors to accomplish the projects goals. ISU and University of Iowa assisted with planting costs; Repreve Renewables, LLC provided plant material and planting equipment; New Holland Agriculture provided equipment leases; and the Bioeconomy Institute, Department of Agronomy, Iowa Energy Center, and Leopold Center for Sustainable Agriculture provided funding and support.

Biomass preparation. The BCRF prepared biomass feedstocks for several internal and external clients (e.g., universities, national laboratories). The farm's biomass preparation lab was used to fine grind, screen, and size the feedstocks. Biomass drying projects were completed as well.

In one particular project, the BCRF milled two metric tons of wheat straw for an off-campus industry client. The straw was milled to 1/32" using the stationary hammer mill and the pilot-scale hammer mill. It was used by the client for a biofuels project.

In another project, Kurt Rosentrater, ABE Department, measured efficiency and other parameters as these relate to drying corn in an innovative low-temperature drying process. David and Joe Loebach from Loebach Brothers Moisture Removal Systems, Inc., invented the system, which was featured in a *Wallaces Farmer* article.

Biomass conversion to value added products. Kurt Rosentrater continued work on a project to replace fish meal and oil in cobia diets with soy ingredients.

Infrastructure and equipment. The new Bio-Polymer Processing Facility was completed and dedicated August 26, 2015. The pilot plant will allow researchers to produce sufficient quantities of biobased polymers derived from vegetable oils for commercialization. The project is led by Eric Cochran, Chris Williams, Gerald and Audrey Olson, ISU engineers, in collaboration with Argo Genesis Chemical, LLC, an affiliated company of Seneca Petroleum in Crestwood, Illinois.

Thermochemical. The BEI continued working on a new Department of Energy-sponsored bio-oil stabilization project with the goal of producing a stable bio-oil that could be integrated into an oil refinery and blended with traditional petroleum feedstocks to make hydrocarbon fuels. The fast pyrolysis process development unit, located in the BCRF thermochemical train, was used to convert biomass feedstocks into distinct bio-oil fractions.

The fast pyrolysis unit also was used for bio-oil production from red oak and clean corn stover feedstocks for internal and external projects. This work was done to explore possible uses for individual fractions, including a path to fermentable sugars.

An ISU research team led by Robert Brown, ISU engineer, was awarded a patent for the fractionation process of the pyrolysis process development unit. The technology has been exclusively licensed to Avello Bioenergy, Inc., an ISU startup company located at the BCRF.

The gasifier has been used to support doctoral research on using switchgrass feedstock. Work included exploration of the operational thresholds of the bubbling fluidized bed reactor and investigation of alternative methods for gasification tar analysis. Research continues in the area of gas cleanup for syngas

fermentation. Equipment has been designed, procured, and assembled in order to evaluate the cleanup technology with a synthesis gas slipstream. Shakedown runs have been completed using model syngas with contaminants and testing with live syngas is planned for 2016.

Commissioning of the front-end of the solvent liquefaction pilot plant has been completed, and products for initial testing have been generated. Construction and mechanical shakedown of the back-end of the system continues as new information is gathered. The plant is in the process of becoming fully functional.

Grants, appropriations, and donations. From its inception in 2009, the BCRF has been well supported by private industry donations. To date, the following companies contributed monetary and/or in-kind support to the BCRF:

- AGCO Corporation
- Argo Genesis Chemical, LLC
- Centocor, Inc. (Johnson & Johnson)
- Country Landscapes, Inc.
- Crown Iron Works Company
- Deere & Company
- DemoDozer, Inc.
- DuPont Cellulosic Ethanol (DCE)
- New Holland Agriculture
- Pioneer Hi-Bred International, Inc.
- Rockwell Automation, Inc.
- University of Northern Iowa National Ag-Based Lubricants Center
- Vermeer Corporation

Through these donations, the BCRF has increased its capabilities in biomass harvest, storage, transport, preparation, and fermentation, and production of bio-oil, syngas, biopolymers, and other products. These donations included construction of three large hoop sheds, a new \$5.3M biopolymer processing plant, grinding and sieving equipment, control systems and software,

fermenters and bioreactors, ancillary equipment, landscape enhancements, and unlimited use of agricultural and industrial equipment.

Visitors and Tours

Information dissemination and promotion was accomplished through tours, conferences, and symposia. Tours were provided for 82 groups with approximately 1,472 visitors in 2015. Since the dedication in 2009, BCRF has hosted 684 tours with 11,553 visitors.

The 2015 tours included visits by the Ames Water and Pollution Control, Iowa Economic Development Authority, Iowa State Chapter of Engineers for a Sustainable World, Lawrence Livermore National Laboratory, National Renewable Energy Laboratory, North American Agroforestry Conference participants, and Marc Rousset, attaché for science and technology at the Consulate General of France at Chicago.

Several companies and other organizations also visited including the following:

- Ag Ventures Alliance
- Annikki GmbH
- Bolton & Menk
- BP p.l.c.
- Cargill
- Cobalt
- Deere and Company
- DuPont
- Elanco
- Exxon Mobile
- Hamilton County Farm Bureau
- Kemin Industries
- Lincolnway Energy
- Nationwide Agribusiness
- New Holland
- Omni Tech International, Ltd
- Phibro Ethanol Performance Group
- Phillips 66 Company

The BCRF also gave numerous tours to students and teachers from K-12 schools as well as the following groups and workshops:

- 4-H STEM students
- Agricultural Education and Science Instructors Professional Workshop
- Boy Scouts of America
- Campfire Canwita Outrageous Day Camp
- CBiRC Biorenewables Workshop for Elementary Teachers
- CBiRC Research Experience for Undergraduates
- CenUSA undergraduate interns
- Continuing Professional Development Division of American Society for Engineering Education
- DMACC agribusiness class
- Iowa Central Career Academy
- Iowa Corn Leadership Enhancement and Development (I-LEAD) Class
- National Association of Engineering Student Councils

Tours also were given to many other students and professors from various community colleges and universities that included Purdue University, the University of Minnesota, and professors from the United Kingdom.

The BCRF was an exhibitor at the 2015 Iowa Renewable Fuels Summit and Trade Show on January 27 in Altoona, Iowa. Many attendees visited the exhibit and were able to see samples of materials produced at BCRF including ground feedstocks, bio-oil, biochar, and torrefied corn stover pellets.

Through close cooperation with the ISU Research Farms, ISU Center for Crops Utilization Research, Ames Convention and Visitors Bureau, BEI, and ISU Foundation, many public organizations, private companies, international organizations, and citizens of Iowa have visited BCRF.