

BioCentury Research Farm Update

RFR-A14115

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Introduction

The BioCentury Research Farm (BCRF) had a diversity of users in 2014. Iowa State University (ISU) faculty and staff from the Departments of Agricultural and Biosystems Engineering (ABE); Agronomy; Biochemistry, Biophysics, and Molecular Biology; Civil, Construction, and Environmental Engineering; and Food Science and Human Nutrition, 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 BCRF. Private industry users of BCRF included AGCO, Avello Bioenergy, Deere & Company, Direvo Industrial Biotechnology, DuPont Cellulosic Ethanol, Frontline Bioenergy, Phillips 66, and Virent, Inc. By the end of 2014, BCRF had over 95 full- and part-time users with projects in all available space. The BCRF also supported numerous class projects and employed the ISU Student Employee of the Year.

Research, Upgrades, and Equipment

A great deal of research project activity occurred at BCRF in 2014. The major activities included the following areas:

- Algae research and production methods
- Biochar research
- Biochemical research that included distillation, fermentation, and related processes
- Biomass feedstock collection and logistics research
- Biomass feedstock preparation
- Biomass conversion to value-added products

- Infrastructure upgrades and equipment acquisition
- 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 biofilm reactor, and various lab-scale reactors. Newer belt designs were added in 2014 and commercial scale research projects were begun. The researchers have the ability to produce 1.3 to 4.5 kilograms of dried algae biomass per week.

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

The diverse algae species grown in the facility are suited for different end uses. For example, algae with high lipid levels are good for producing biodiesel, and algae with high protein levels and good amino acid profiles are good livestock or fish feed.

Biochar. Approximately 70 kilograms of biochar was applied to half of a 30 ft × 60 ft field plot located in the BCRF demonstration plot area called the “Plant Zoo.” As in 2013, sorghum-sudangrass was planted in the plot to compare the yields of the treated and untreated areas and conduct postharvest soil tests.

Biochemical. Multiple biochemical projects were completed at BCRF in 2014. These projects included fermentation and distillation work as well as corn ethanol process improvement and work with butanol distillation.

Biomass feedstock collection. Multiple projects continued in this area in 2014 with the most notable ones related to the DuPont Cellulosic Ethanol (DCE) and POET-DSM Advanced Biofuels research support efforts led by Matt Darr and Stuart Birrell, professors of agricultural and biosystems engineering.

For the DCE project, work continued in the area of corn stover bale collection. This effort included a combination of the ISU stover harvest team, DCE harvest teams, and a custom harvest subcontractor. The BCRF received numerous bales for observation, and ash and moisture content sampling. Over 11,000 bale samples were processed during the 2014 harvest.

Ongoing stover harvest supply chain training continued throughout 2014 to improve collection efficiencies and reduce costs. Results of the training showed a 4.5 percent increase in stover product density. This improvement is expected to reduce the number of semi-trucks on Iowa roads by more than 1,200 per year.

The POET-DSM plant began production in 2014 and the new DCE plant is expected to come on line in 2015.

Agricultural product development and research support for several major agricultural equipment manufacturers continued throughout the entire year. New Holland Agriculture continued to provide ISU the use of two tractors and a baler for the purpose of quantifying the efficiency and other parameters of one of its square baler models. The tractors remained at BCRF for general use throughout 2014 and will continue for the foreseeable future. New projects included work in the area of forage crop harvesting.

ISU Extension and Outreach released a series of fact sheets to help producers learn about the

engineering, agronomic, and financial issues related to corn stover harvest. The fact sheets were prepared by the ISU corn stover harvest team that included Matt Darr, Mark Hanna, and Stuart Birrell, of ABE, and Darren Jarboe, CCUR program manager. The 21 fact sheets can be downloaded from the ISU Extension stover harvest web site.

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

Biomass conversion to value added products. Kurt Rosentrater, ABE and BCRF affiliate, and Darren Jarboe, CCUR program manager, led a team trying to turn food waste into animal feed ingredients. The team utilized food waste from ISU Dining, mixed it with corn stover at the University Compost Facility, and then dried the mixture using the BCRF's large cyclonic Tempest Drying System. Approximately 2,000 pounds of food waste was processed and dried in September. Follow-up trials will begin in 2015.

Rosentrater also worked on a project to replace fish meal and fish oil in cobia diets with soy ingredients. At the BCRF, his team used the pilot-scale hammermill to grind ingredients. The mixture then was extruded using CCUR's InstaPro single-screw extruder. The feed pellets were brought back to the BCRF and dried. The soy-based pellets will be used in feeding trials at Hubbs-SeaWorld Research Institute in San Diego, California.

Infrastructure and equipment. Upgrades to the existing ventilation system continued in 2014. The upgraded ventilation system will assist with a Department of Energy sponsored project led by BCRF affiliate Robert Brown, Mechanical Engineering Department. The

upgrades were funded by ISU's "Leading the Bioeconomy" initiative supported by an appropriation from the Iowa Legislature. This project was completed in 2014.

An emergency generator was added to the electrical system of the Processing Building. The generator was jointly funded by BEI and the ISU Ag Experiment Station.

Construction began on a new biopolymer processing plant as a result of a joint ISU-industry partnership. Chris Williams, Civil, Construction and Environmental Engineering, and Eric Cochran, Chemical and Biological Engineering, have led efforts to develop a family of new biobased polymers derived from vegetable oils. Their work will culminate in the construction and operation of a large pilot-scale plant that will be located at the BCRF. Completion of the pilot plant is expected in mid 2015.

A Caterpillar telehandler (model TH406C) was purchased to perform various tasks at the BCRF including handling corn stover bales. The purchase was made possible through the "Leading the Bioeconomy" initiative.

Thermochemical. The BEI continued working on a new Department of Energy-sponsored bio-oil stabilization project with the goal to produce 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 four distinct bio-oil fractions.

The fast pyrolysis unit also was used for bio-oil production using red oak and clean corn stover feedstocks for both internal and external projects. This work was done mainly to explore possible uses for individual

fractions, including a path to fermentable sugars.

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

The gasifier has been used to support a student's 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. BEI relocated a combustion unit from Black Engineering to burn the syngas as it is produced and made other improvements.

Grants, appropriations, and donations. From its inception in 2009 through 2014, 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

harvesting, bulk storage, transport, preparation, and fermentation, and production of bio-oil, syngas, and other products. These donations included construction of three large hoop sheds, grinding and sieving equipment, control systems and software, fermenters and bioreactors, other ancillary equipment, landscape enhancements, and unlimited use of several pieces of agricultural and industrial equipment.

Visitors and Tours

Information dissemination and promotion was accomplished through tours, conferences, and symposia. Tours were provided for 103 groups with approximately 2,435 visitors in 2014. Since the dedication in 2009, BCRF has hosted 600 tours with 10,086 visitors.

The 2014 tours included visits by congressional aides, DSM Community Youth Concepts, Extension Energy and Environmental Summit, Hertz Farm Management, Hebei Chinese delegation Midwest Ethanol Plant Managers, Regent Bruce Rastetter, and Urban Ag Academy for State Legislators.

Several companies and other organizations also visited including AGCO, Cobalt, Deere and Company, DuPont, Emerson, MeadWestvaco, Nationwide, New Holland, and Vermeer.

The BCRF also gave numerous tours to students and teachers from K-12 schools around the state as well as Climate Change Workshop, STEM camp, Iowa 4-H Youth Conference, Ag in the Classroom, Webster County Leadership Group, FFA, and students and professors from various community colleges and universities.

Approximately 646 visitors were hosted by the Ames Visitors and Convention Bureau in 2014. BCRF hosted seven field days totaling 1,122 visitors. There were 401 visitors from the Farm Progress Show who toured the BCRF.

BCRF was an exhibitor at the 2014 Iowa Renewable Fuels Summit and Trade Show on January 28 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 ISU Research Farms, Ames Convention and Visitors Bureau, BEI, and ISU Foundation, many public organizations, private companies, educational organizations, international organizations, and citizens of Iowa have visited BCRF.