



cenusa bioenergy

Annual Progress Report

Agro-ecosystem Approach
to Sustainable Biofuels Production via
the Pyrolysis-Biochar Platform

February 2013

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NOTICE

This quarterly report was prepared by Iowa State University and CenUSA Bioenergy research colleagues from Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, and the University of Wisconsin in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the United States Department of Agriculture National Institute of Food and Agriculture (“USDA-NIFA”).

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Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)

Quarterly Report: November 1, 2012 – January 31, 2013

PROJECT ADMINISTRATION

1. Project Organization and Governance Accomplishments

Ken Moore (Professor, Iowa State University) is the CenUSA Bioenergy Project Director. Anne Kinzel (Chief Operating Officer) and Val Evans (Financial Manager) handle project administration and business affairs, including project coordination, communication, and data sharing among institutions across the states. In addition, Kinzel is responsible for the day-to-day project management including the preparation quarterly and annual progress reports, meetings, and maintenance of the project's public face (website/social media outlets). Evans continues to be responsible for all project financial activities, including the development and implementation of administrative policies and procedures to ensure effective financial operation and oversight of the project.

As we enter the midpoint of our second year of CenUSA activities we are confident that each of the nine CenUSA objectives is showing satisfactory progress towards meeting CenUSA's deliverables schedule. This quarter has seen a number of important activities take place. We have featured a few to discuss in this project organization and governance section as they involve all objectives working together towards our project goals.

Featured Second Quarter Activities

- **Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest**

The workshop *Roadmap to Commercialize Thermochemical Biofuels and Bio-Processing in the Midwest* was held December 11-12, 2012 at Iowa State University in Ames, Iowa. CenUSA, the ISU Bioeconomy Institute, the USDA Central-East Regional Biomass Research Center, Iowa NSF EPSCoR, and the Iowa Energy Center sponsored the workshop (See Exhibit 1. Workshop Agenda and Attendee List).¹

Workshop Focus: Optimal Feedstocks and Commercial Pathways. The workshop had three primary goals:

1. Foster relationships between CenUSA researchers, other interested faculty, Midwest agricultural producer groups, and the thermochemical processing industry.

¹ Iowa EPSCoR is funded by grant number EPS-1101284 from the National Science Foundation. Information is available at <http://iowaepscor.org/>

2. Identify optimal biomass feedstock characteristics for thermochemical processing of biomass.
3. Identify commercial pathways for thermal chemical processing of herbaceous biomass to in the Midwest region.

Beyond these broad goals we designed the program to focus on the following objectives:

1. Identifying commercial pathways for thermochemical technologies in the Midwest.
2. Providing a forum for representatives leading companies in commercialization of thermochemical processing of biomass to share their technologies, goals, desired type of feedstock, and amount of biomass needed for commercial operation.
3. Providing a panel of experts on plant breeding and agronomy to describe how different agricultural approaches can be used to optimize the yield of biomass feedstocks while minimizing undesirable components such as ash, nitrogen, and moisture.
4. Having experts from Iowa State University and the USDA discuss non-fuel products such as heating oil, biochar, and bioasphalt that can be made by thermochemically processing biomass.
5. Bringing together representatives from agricultural producer groups to describe to industry representatives and academic researchers how they brought past bioenergy projects to fruition and their criteria for new projects.

Tables 1, 2 3 and 4 show the technologies and attendees represented at the workshop.

Table 1. Technologies Represented	
ADM	Acetic Acid Pulping
BP	Gasification
Chevron	Solvent Liquifaction
GTI	Pyrolysis
KiOR	Catalytic Pyrolysis
ICM	Gasification
P66	Pyrolysis
Renmatix	Solvent Liquifaction
UOP	Pyrolysis
Virent	APR/ Catalytic

Workshop Methodology. Jill Euken (CoPd Extension and Outreach) and Anne Kinzel worked with Andrew Larson (ISU SARE Coordinator) on a workshop plan. With the participants' diverse backgrounds and broad range of technical competence, we wanted to find the best method for participants to share their thoughts as quickly and as expansively as possible. With Larson's expertise we were able to put together an entire workshop script devoted to interaction (See Exhibit 2. CenUSA Facilitated Discussion).

Table 2. Industry Representatives	
Rod Backhaus	Producer - Tall Corn Ethanol
Manuk Colakyan	Renmatix
Bill Couser	Lincolnway Energy
Bob Freeman	Frontier Labs
Paula Hassett-Flowers	UOP
Andrew Held	Virent
Mark Hughes	P66
Byron Johnson	P66
Dmitry Kazachkin	Renmatix
Paul Keeney	Producer - KAAPA
Mark Laurenzo	Producer - IDEA
Frank Lipiecki	Renmatix
Terry Marker	GTI
Peter Metelski	BP
Brad Petersburg	Producer - Ag Ventures Alliance
Magdalena Ramirez	KiOR
Howard Roe	Producer - Tall Corn Ethanol
Bob Rozmiarek	Virent
Rusty Schmidt	Producer - Ag Ventures Alliance
Harry Stine	Producer - Stine Seeds
Jeff Stroburg	Producer - West Central Coop
Rod Williamson	Iowa Corn Growers
Michelle Young	Chevron

Table 3. CenUSA Advisory Board	
Bert Bennett	ICM
Tom Binder	ADM & Advisory Board Chair
Denny Harding	Iowa Farm Bureau
Bryan Mellage	Mellage Truck & Tractor/ C-Minus
LaVon Schiltz	Nevada Economic Development Council
John Weis	Agricultural Producer

Table 4. Academic Attendees: Professional Specialty and Interest	
Sorrel Brown	CenUSA Co-PD & Evaluation Specialist (ISU/Agronomy)
Mike Casler	CenUSA Co-PD – USDA ARS
Kendall Lamkey	Agronomy (ISU)
David Laird	CenUSA Co-PD (ISU/Agronomy)
Thomas Lubberstedt	Director, ISU Baker Center for Plant Breeding
Ken Moore	CenUSA PD (ISU/Agronomy)
Marty Schmer	USDA (ARS/Agronomy)
Ken Vogel	CenUSA Co-PD (ARS/Plant Geneticist)
Chris Williams	CCEE (ISU)
Mark Wright	Mechanical Eng. (ISU)
Stuart Birrell	CenUSA Co-PD (ISU/Ag. & Bio Eng.)
Robert Brown	Mechanical Eng. (ISU)
Laura Jarboe	Chemical & Biological Eng. (ISU)
Rob Mitchell	CenUSA Co-PD & USDA - ARS
Raj Raman	CenUSA Co-PD (ISU/Ag. & Bio Eng.)
Jeff Volenec	CenUSA Co-PD (Purdue/Agronomy)
Dermot Hayes	CenUSA Co-PD (ISU/Ag. Economist)
Keri Jacobs	CenUSA Co-PD (ISU/Ag. Economist)

Workshop Outcomes. Our script did yield lively interaction between the participants which was well captured in the *Roadmap to Commercialize Report* (See Exhibit 3. Roadmap to Commercialization Report), and in the Workshop Evaluation Report (See Exhibit 4. Workshop Evaluation Report). The responses in the *Roadmap to Commercialization Report* demonstrates the participants were very engaged with each other and willing to offer many thoughtful suggestions and observations.

The workshop's key takeaway points include:

- The thermochemical industry is moving towards commercialization and is robust enough to handle diverse feedstocks.
- Agronomic practices can be improved by collecting and processing cellulosic material.
 - Stover collection is needed on some fields
 - Biochar addition improves soil and yields

- The fact that a vast array of companies and individuals are working towards the same goal creates an atmosphere for things to get done.
- There is farmer cooperative interest in partnering with and supplying the thermochemical industry.

Participants also made the following key recommendations:

- Create a multi-industry consortium, develop a shared vision, promote R&D, etc. to widely engage geographically diverse supply chain and stakeholders groups.
- Promote education and communication between producers and industry so that risks are understood and options can be developed to address risk.
- Look at vertical integration that identifies the specifics of the processes that need improvement.

Key Post-Workshop Follow-Up Actions. As we had hoped, the workshop helped create some new working relationships between the CenUSA research team, agricultural producer industry participants. These enhanced relationships yielded these promising results:

- **Participation in the 2013 CenUSA Annual Meeting.** Based on comments and suggestions made during the workshop we will be inviting selected participants to take part in the 2013 CenUSA Bioenergy Annual Meeting (July 30 - Aug. 2, 2013). This will provide further opportunity for interactions between CenUSA researchers and industry. We are aware that industry representatives are especially interested in the meeting's field tours which will be conducted at Purdue University facilities and sites near West Lafayette, Indiana. Complete information regarding this meeting is provided in Section 1.a below.
- **Environmental Interest Group Workshop.** CenUSA will host a workshop in Minnesota for environmental interest groups in the summer or fall of 2013. CenUSA CoPd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools) will lead this effort. Hill will also apply for a USDA-NIFA conference grant to support the event. This meeting was a direct outcome from discussions that took place at the CenUSA Bioenergy mid-year meeting that took place immediately following the Commercialization Workshop.
- **Data and Material Sharing.** Based on the participants' comments and observations from the CenUSA research team, we prepared a brief survey to share with industry

participants (See Table 5 and “CenUSA Planning & Collaboration Meeting”). The survey was sent out the second week of January 2013.²

Initial survey results have participants expressing interest in advancing the performance of herbaceous biomass in thermochemical processing by participating in one or both of the following activities:

- Testing Midwest-produced herbaceous biomass in their system, and
- Sharing data from prior tests with herbaceous biomass in their particular process.

Table 5. Post-Workshop Industry Survey	
1. Would you be interested in testing herbaceous biomass materials produced in the Midwest in your bench or pilot processing equipment if the material is provided to you at no cost and is well characterized? * If you answer “no,” please skip to question 6.	
2.a. What quantity switchgrass feedstock would you need in order to conduct the tests? (In Tons)	
2b. What quantity Indian Grass feedstock would you need in order to conduct the tests? (In Tons)	
2c. What quantity Big Blue Stem feedstock would you need in order to conduct the tests? (In Tons)	
2d. What quantity corn stover (single pass, clean) feedstock would you need in order to conduct the tests? (In Tons)	
3. Please specify the acceptable particle size range	
4. When would you like to receive the materials?	
5. [Demographic Questions]	
6. Has your company already conducted tests with herbaceous biomass in thermochemical processes? (If you answer “yes,” please answer question 7 as well.)	
7. Would you be willing to share information about how herbaceous biomass performed in your process and your wish list for characteristics to optimize performance in your system(s)?	

Table 6. Initial Industry Survey Responses	
ADM	ASAP: CenUSA to provide small bales or 1 kg of each of the types of biomass. By 8/1/13 provide big bales of each of the types of biomass.
KiOR	By 4/30/13: CenUSA to provide Switchgrass, Indian Grass, and Big Blue Stem samples.
Catchlight	Has already conducted tests with herbaceous biomass and will provide CenUSA with their existing data.

² <https://docs.google.com/spreadsheets/viewform?formkey=dGJuQ3RHZjhFOFFVmh4SkFJRkZfX1E6MQ#gid=0>

Workshop Evaluation. We were especially pleased with these evaluation findings:

- 85% of the evaluation respondents indicated their understanding of ideal feedstock characteristics for thermochemical processing had improved after attending the workshop
- 88% of respondents found the length “just right”.
- 82% found the workshop’s general technical content to be “about right.”

a. CenUSA Planning & Collaboration Meeting – December 12-13, 2012

Immediately following the Roadmap Workshop, the CenUSA executive team met in Ames to discuss CenUSA commercialization and transdisciplinary opportunities. The discussions allowed the executive team to fully flesh out what they learned in the workshop. The discussion was made livelier as each of the CoProject directors presented their observations from the standpoint of their own individual disciplines and research interests. USDA-NIFA program contact Bill Goldner facilitated significant portions of the discussions and provided direction for the project’s future.³

This meeting also provided the impetus for the post-meeting industry survey above. Participants agreed to work together to provide industry with the requested material.

a. Advisory Board

The Advisory Board continues to provide valuable feedback and advice to the research team. We invited selected Advisory Board members to the Roadmap Workshop. As they have throughout the project, the Advisory Board actively participated in the workshop.

New Board Member. In December 2012 board member Tim McCoy submitted his resignation. Due to a promotion he believed he was unable to devote sufficient time to CenUSA activities. McCoy, as a leading official at the Nebraska Game and Parks Commission, was our wildlife expert on the Board. At McCoy’s suggestion we invited Eric Zach, Ag Program Manager at the Nebraska Game and Parks Commission to join the Board. Zach, who also has an extensive background Midwestern wildlife management agreed to join the Board in late January 2013. (See Exhibit 5. Eric Zach Bio)

2. Coordination, Collaboration, and Communication

- **Executive Team Meetings and CenUSA Research Seminar.** The Co-Project directors representing each of the nine objectives continue to meet monthly with Ken Moore, Anne

³ National Program Leader, Sustainable Bioenergy, AFRI

Kinzel and Val Evans via online meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows for documents to be viewed by all participants, enhancing communications and dialogue between participants. Tom Binder, the Advisory Board chair also attends these meetings, to ensure there is an Advisory Board presence during these important project gatherings.

Starting in January 2013, we began holding the *CenUSA Research Seminar Series* to coincide with the monthly Co-Project director meeting. The Research Seminars are held in the CenUSA Adobe Connect meeting room immediately following the monthly executive team meeting.

Each seminar focuses on the work of a CenUSA objective. We begin the seminars with a 15-minute talk by a project Objective Co-project director followed by a 15-minute graduate presentation(s). The seminars conclude with 20 minutes of question and answer time.

Our first seminar will be held February 22, 2013 and will feature the Feedstock Development Objective. CoPd Mike Casler. Casler's presentation "Twenty years of switchgrass improvement to create a dedicated bioenergy crop" provide a summary of the progress made between 1992 and 2002 in Lincoln, NE and Madison, WI to improve biomass yield of switchgrass and concluded with how that work has a direct tie-in to the CenUSA research effort. Graduate students Emily Rude and Guillaume Ramstein's presentation, "Genomic selection to improve biomass yield of switchgrass" will review efforts to develop a genome-wide DNA-marker platform to improve the efficiency and rate of gain for increasing biomass yield of switchgrass.

- **Objective and Team Meetings.** All nine CenUSA Objectives continue participate in scheduled and ad hoc meetings using the CenUSA Adobe Connect meeting room or in face-to-face meetings. The five Extension and Outreach Objective teams also meet via Adobe Connect or face-to-face gatherings.⁴
- **2013 Annual Summit.** The advance planning for the 2013 annual summit is complete. The meeting will be held July 30 - August 2, 2013 in West Lafayette, Indiana. Jeff Volenec, Professor in the Department of Agronomy at Purdue University and Co-Project Director of CenUSA's Sustainable Feedstock Production Systems Objective, will host the 2013 Summit. We will be including an expanded roster of guests relative to our 2012 meeting. We have invited industry participants (See p. 6) and anticipate a strong contingent of graduate students now that our educational efforts are more fully underway.

⁴ The teams are Broader Public/Master Gardener/Youth Programs, Economics and Decision Tools, Evaluation/Administration, Extension Staff Training/eXtension, Health and Safety, and Producer Research Plots/Perennial Grass. For more information see www.cenusa.iastate.edu/Outreach.

- **Communication Platforms.** CenUSA continues to focus on expanding the quality and sophistication of the CenUSA website (www.cenusa.iastate.edu) and other social media opportunities.

The website has been upgraded and now features a redesigned home page. The home page provides a new “Events Calendar”, and enhanced new ticker and improved “News” and “Collaborators” sections. These home page enhancements provide the public with better insight into the CenUSA project, and most importantly, the changes allow us to better promote CenUSA events and activities such as educational meetings, webinars, media events, eXtension bioenergy learning modules, field days, and networking opportunities.

On the website’s pass word-protected area we have a new calendar available to all CenUSA participants. The calendar is able to provide information on CenUSA meetings and helps the project stay organized.

We have used a Twitter account (@CenUSAbioenergy) to provide project updates, and disseminate information regarding the availability of CenUSA publications. We continue to increase our number of Twitter followers within the biofuels/bioenergy community.

Webinars/Videos. Our project webinars and videos are disseminated via three separate sites to provide multiple outlets to view CenUSA-webinars and videos: 1) the CenUSA website, 2) a CenUSA Bioenergy “YouTube Channel”

(www.youtube.com/user/CenusaBioenergy) and 3) a CenUSA Bioenergy Vimeo site (<https://vimeo.com/cenusabioenergy>) to provide an additional outlet to view CenUSA webinars and videos.

We added two videos to our sites this quarter:

- ✓ **How to Measure Stand Establishment Using a Grid** (December 28, 2012)
CenUSA Bioenergy collaborator and University of Nebraska-Lincoln Extension Educator John Guretzky demonstrates how to use a grid to measure perennial grass stand establishment in this training video. (<http://youtu.be/AXZN7-PmldU/> <https://vimeo.com/55131669>)
- ✓ **Optimizing Harvest of Perennial Grasses for Biofuel** (January 18, 2013)
CenUSA co-project director and University of Wisconsin professor Kevin Shinnars discusses new systems to harvest, handle, store and transport perennial grasses that will be used as biomass feedstocks. Video produced by Pam Porter, University of Wisconsin Environmental Resources Center in partnership with the Division of Information Technology (available at <http://youtu.be/NMt5Ct-65-Y> and <https://vimeo.com/57621501>).

- **Financial Matters.** The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements.
- **Program Matters.** We will continue to focus on project coordination, communication, meetings and data sharing across Objectives, and on reaching the revised timelines milestones.

GERMPLASM TO HARVEST

Objective 1. Feedstock Development

Feedstock Development focuses on developing perennial grass cultivars and hybrids that can be used on marginal cropland in the Central United States for the production of biomass for energy. In 2012, the focus is on the establishment of new breeding and evaluation trials.

1. Significant Accomplishments Summary

CenUSA funding enabled the ARS breeding projects at Lincoln, Nebraska and Madison, Wisconsin to complete a third year of testing of previous established yields tests in three Midwest states. CenUSA funding also enabled this Objective's ARS-Lincoln project team to increase breeder seed under irrigation of a high-yielding, lowland type experimental switchgrass strain with very good winter hardiness that was identified in these trials. This strain, which has the experimental designation 'KxS HP1 NETO2 C1' has had excellent winter survival and high biomass yields throughout the region. In a trial near Spooner in northern Wisconsin, it had excellent winter survival and produced 11.7 Mg ha⁻¹ biomass and had greater yields than all released cultivars in the trial. At Spooner, the lowland cultivar Kanlow and all Kanlow derived experimental strains winter killed. At DeKalb, Illinois, it produced 15.5 Mg ha⁻¹ biomass, which was three Mg ha⁻¹ greater than other cultivars in the trial. In eastern Nebraska, its average annual biomass yield for 2009 through 2011 was 18.1 mg ha⁻¹ (8 tons/acre), which was 2.4 tons per acre greater than that of best available released upland cultivar. In 2012, 27 kg (60 lbs.) of breeder seed was produced which will be used to establish a Foundation Seed field under irrigation in 2013. The capability to produce seed under irrigation was critical in 2012 because of the severe drought. The University of Nebraska's Foundation seed division, *Husker Genetics*, will manage the Foundation seed production. The experimental strain is being processed for official release in 2013. It will be the first biomass type lowland cultivar that is well adapted to Midwestern winters (Ken Vogel, CenUSA Co-Pd/ARS-Lincoln and Mike Casler, CenUSA Co-Pd /ARS-Madison).

In addition to providing data to support the release of a new cultivar, the field trials and their analyses, which were completed in January 2013, produced some basic information documenting switchgrass breeding gains for biomass yield. The information gained is

summarized below. This research is being prepared for publication (Ken Vogel and Mike Casler).

- **Breeding for Biomass Yield in Switchgrass.**

- ✓ Selection and breeding within WS4U upland switchgrass increased biomass yield by 4% per year for a simple phenotypic recurrent selection program that required only two years per generation.
- ✓ Selection for biomass yield and winter survival within Kanlow lowland switchgrass increased biomass yield by 2% per year. Because selection was conducted within USDA Hardiness Zone 5, the yield gains were successfully observed in other HZ5 locations, but not at locations within HZ3 or NZ4.
- ✓ Selection for biomass yield and winter survival within Kanlow x Summer hybrid populations resulted in third-generation populations with superior biomass yield and survivorship across HZ3 through HZ5, combining the best traits of both the upland and lowland parents. On average, the hybrid populations had 43% higher biomass yield than the better of the two parents, regardless of the location.
- ✓ All of the gains in biomass yield were associated with increases in biomass quality traits on a per-hectare basis, e.g. higher yield of ethanol per hectare and more combustible energy produced per hectare.
- ✓ Genetic increases in biomass yield were all measured at a constant amount of N fertilizer. As such, in the strictest sense of the term, all increases in biomass yield were a result of increased nitrogen-use efficiency (NUE). While N concentration of the biomass did not change as a result of selection, total N removed in the biomass increased in direct proportion to the increases in biomass yield. On average, each additional Mg/ha of biomass drew an additional 5-12 kg/ha of N from the soil.

- **Integrated Project Impact:**

Because of the promising early results from these trials, the experimental strain KxS HP1 NETO2 C1 was included in all the regional small plot yield tests established in 2012 and in the CenUSA Objective *Sustainable Feedstock Production Systems* factor analysis trials, which were also established in 2012. All previous switchgrass management research in the Midwest has been conducted with upland cultivars developed primarily for use in pastures that have lower biomass yields. The data from these trials will be the first data for use in economic and system analyses for high yielding biomass type switchgrass adapted to the Midwest. All previous analyses have been done using data

based on switchgrass cultivars developed for use in pastures. The biomass samples from these plots and trials also will be used in the CenUSA conversion research.

2. Planned Activities

- Biomass samples collected during the summer and autumn of 2012 will be dried, ground, and scanned for their NIRS spectral profiles. Selected samples will be selected for laboratory analyses by ARS-Lincoln; comprehensive compositional analyses by Bruce Dien (CenUSA Collaborator/ARS-Peoria) and pyrolysis by Akwasi Boateng (CenUSA Collaborator/ARS-Wyndmoor) will be initiated.
- Clonal pieces of switchgrass plants will be moved from the field to the greenhouse for intermating during the winter months (Ken Vogel).
- Seed harvested during the autumn of 2012 will be cleaned and tested. Seed of one experimental strain will be made available for seed producers pending official cultivar release (Ken Vogel and Mike Casler).
- Plant Canada milkvetch seedlings in the greenhouse for four breeding populations for potential use in different Midwest Plant Adaptation Regions. Plant seedlings for Partridge Pea selection nurseries (Ken Vogel).
- Insect sampling plans will be developed for the summer of 2013 (Tiffany Heng-Moss, CenUSA Collaborator/UNL, Ken Vogel, Rob Mitchell, CenUSA Co-Pd/ARS Lincoln, Ken Vogel, and Mike Casler). We will continue identification of insects collected in 2012.
- Complete statistical analyses of 2012 virus ratings of switchgrass genotypes (Gary Yuen, Collaborator/UNL and Ken Vogel).
- Continue to screen selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids (Tiffany Heng-Moss, UNL).
- **Compositional analyses.** Complete training of technician in plant cell wall compositional analysis and initiate full laboratory composition analyses capacity (Bruce Dien).
- Continue py-GC/MS and TGA experiments and associated statistical analysis on 2012 sample sets of switchgrass. Prepare for initial analyses of big bluestem, and indiangrass samples.

- Initial draft of manuscript on effect of genetic differences in biomass composition of 12 divergent switchgrass genotypes on pyrolysis products completed for review.

3. Actual Accomplishments (Planned Activities)

• **Breeding & Genetics – Lincoln, Nebraska (Ken Vogel)**

- ✓ In 2012, over 8000 biomass samples were collected for analyses. All drying and weighting work has been completed and over half of the samples have been ground. Grinding work is expected to be completed in March 2013. NIRS scanning work for the Lincoln samples is in progress. A CenUSA funded laboratory research technologist position was re-filled at Lincoln and should enable the NIRS work to be completed. A set of lowland switchgrass samples which differ significantly in lignin and total ash concentration were selected from a switchgrass genetic study for compositional analysis and micro-pyrolysis analyses. The study is designed to determine the effect of genetic and compositional differences on pyrolysis yields from lowland biomass type switchgrass. The samples have been sub-divided and a set of subsamples were sent to Bruce Dien and Akwasi Boateng in early March for analysis of composition and pyrolysis products, respectively. One set will be used at Lincoln for fiber, total C, N, and calorie analysis. Another set of samples based on harvest procedures and methods is being developed.
- ✓ Clonal pieces or ramets of switchgrass plants selected from three different source populations, both upland and lowland, were moved into the greenhouse, flowering induced via lighting control to synchronize flowering periods, and paired plant crossing was initiated at Lincoln. Previously, paper pollination bags developed for use on sorghum were used in making controlled crosses with switchgrass with variable success. The paper pollination bags are often too small for the switchgrass panicles and the panicles have to be trimmed. For these crosses, fabric pollination bags were made using a polyester fabric than has a 41-micron mesh opening. Switchgrass pollen ranges in size from 45 to over 50 microns in diameter. The fabric pollination bags that were made are 60 cm in length and 15 cm in diameter. They keep pollen inside the bag but allow air movement through the bag.
- ✓ All seed harvested in 2012 from field polycross nurseries and seed increase fields has been cleaned as scheduled and seed quality tests have been initiated. Seed production in non-irrigated isolations in Nebraska was adversely affected by the drought in 2012.
- ✓ Canada milkvetch seed increase nurseries were grown under irrigation in 2012. Seed was harvested from all nurseries and seed cleaning has been completed. Sufficient seed was obtained from the hardiness zone populations to support germplasm release and research needs. The seed production objective was met without needing to

establish additional transplanted nurseries of Canada milkvetch as originally planned. Seed was also harvested from plants in three different maturity groups in a genetically broad based Partridge Pea selection nursery and has been cleaned. The seed will be used to establish additional selection nurseries in 2013. These selection nurseries will be established using greenhouse-grown seedlings.

- **Breeding & Genetics - Madison, Wisconsin (Mike Casler)**

See the summary on “Breeding for Biomass Yield in Switchgrass” in the Significant Accomplishment Summary section above.

- ✓ **Progress in developing DNA markers for genomic selection in switchgrass.**

Development of the exome capture pipeline for detecting and evaluating DNA markers of switchgrass breeding populations was completed. Simulation studies of various levels of multiplexing genotypes within a single lane of an Illumina Sequencer revealed that the loss of information with 12-plex or 24-plex coverage falls within acceptable limits. Multiplexing at the 12-plex level led to an average genome coverage of 110Mb (6% of the entire genome), including approximately 1.3 million SNP (single-nucleotide polymorphism) markers read at a depth of two or more reads and 1 million SNP markers read at a depth of five or more. The results of these simulations indicate that between 12 and 24 different genotypes can be sequenced in a single lane without compromising the integrity of the genomic selection protocol.

- **Entomology - Univ. Nebraska - Lincoln (Tiffany Heng-Moss)**

- ✓ During the 2012 growing season, both pitfall traps and yellow sticky insect traps were used in CenUSA breeding, management, and seed production nurseries in Eastern Nebraska. Arthropods collected in the pitfall traps have been sorted and identified and identification and characterization of the arthropods collected on the sticky traps will be completed by the end of March 2013. Data will be summarized to identify potential pests and beneficial arthropods and characterize their seasonal abundance.

- ✓ Greenhouse screenings were continued in which selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains were evaluated for their susceptibility to greenbugs and sugarcane aphids. To date, ‘Kanlow’ switchgrass exhibits the highest level of resistance to the both aphids.

- **Plant Pathology – Univ. Nebraska - Lincoln (Gary Yuen)**

- ✓ **Initiate work on identifying virus species causing severe symptoms on some plants in the field and begin conducting statistical analyses of disease severity data.** Leaf samples collected in July 2012 from four breeding nurseries and a large

genetic field study were tested via commercial immunoassay kits for the presence of six known viral pathogens of switchgrass: panicum mosaic virus (PMV), sugarcane mosaic virus (SMV), wheat streak mosaic virus (WSMV), and barley yellow dwarf virus (BYDV) serotypes rpv, pav and mav. PMV was the most prevalent virus, detected in 87% of 120 samples from plants exhibiting severe virus symptoms. The incidence of other viruses in the same set of samples was much lower: BYD-rpv, 7%; SCM, 6%; BYD-pav, 2%; BYD-mav, 1%; and WSM, 0%. Preliminary analysis of virus severity data from the four breeding nurseries revealed incidences of virus infection ranging from 48 to 59 percent of the plants, with the incidences of plants with severe virus symptoms (mottling in all of the foliage and stunting) ranging from 8 to 24 percent.

- ✓ **Initiate testing of fungal and bacteria stains isolated from diseased leaves for pathogenicity on switchgrass.** Preliminary testing of bacterial isolates revealed several isolates able to cause mild necrosis upon artificial inoculation of switchgrass seedlings. These isolates will be identified following confirmation of pathogenicity. Fungi isolated from diseased leaves were identified as belonging to several genera previously reported in switchgrass (e.g. *Alternaria*, *Bipolaris*, *Fusarium* and *Phoma*).
- ✓ **Initiate work on isolating fungi from diseased crown and root tissue of switchgrass.** Fungi isolated from switchgrass crowns and roots include *Fusarium* and *Pythium*, which are known to be common root-infecting organisms. Methods for testing isolated fungi for infection of switchgrass roots are being developed.

- **Compositional Analyses – ARS-Peoria, (Bruce Dien).**

A technician has been hired and has been trained to carryout analysis. An HPLC-PAD has been setup using a newly released column by Dionex developed for biomass analysis. The HPLC-PAD has been validated for measuring sugar concentrations (Figure 1. Calibration curve for various measured sugars as detected by HPLC-PAD).

The column gives baseline separation of sugars present in the standard (Figure 2A. Figure 2A. Chromatogram of standard sugars acquired on the Dionex system) and acid-digested biomass samples (Figure 2B. Chromatogram of switchgrass cell wall carbohydrate sample acquired on Dionex system). A calibration biomass sample set has been collected that includes switchgrass (5 samples), Reed Canary Grass (1 sample, used as representative of cool season grasses), indiagrass (1), and Bluestem Grass (1). They are currently being analyzed for soluble sugars, fructans, starch, structural carbohydrates, Klason lignin, and total ash. Fructans were not detected in significant amounts in switchgrass, indiagrass, and big bluestem and therefore will not need to be measured for these samples. For measurement of some of the other components, the relative standard

deviations were above 15% and the protocols are currently being modified to improve accuracy. See figures below.

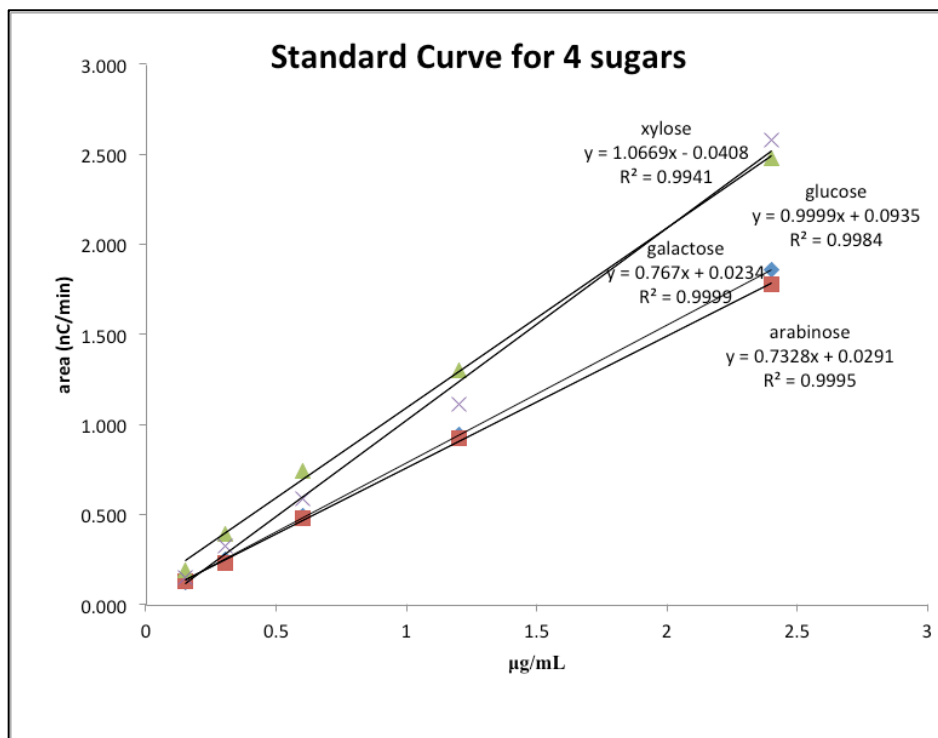


Figure 1. Calibration Curve for Various Measured Sugars as Detected by HPLC-PAD

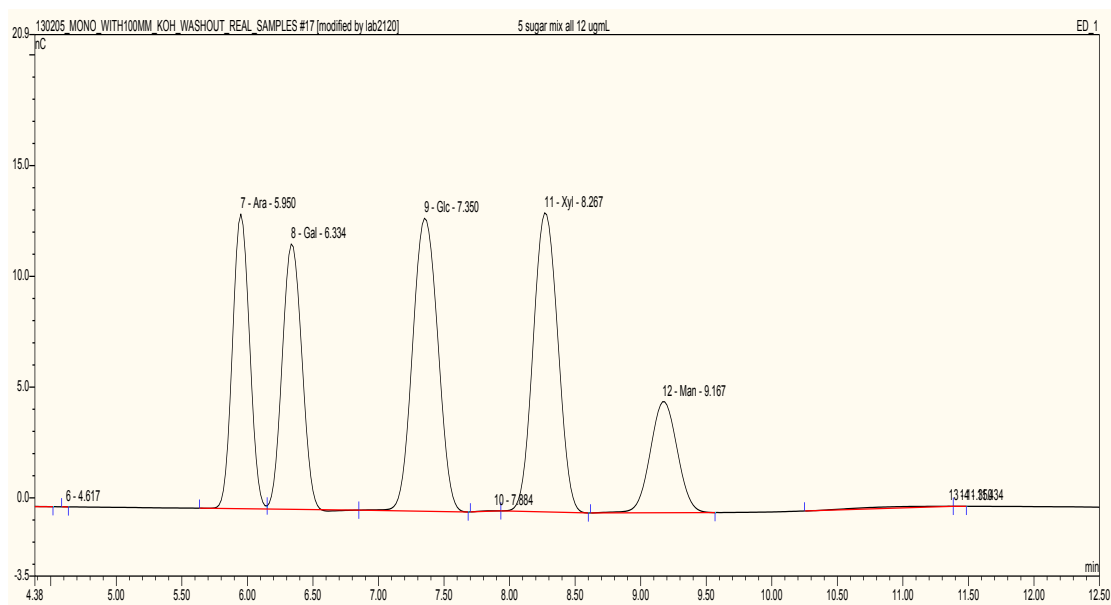


Figure 2A. Chromatogram of standard sugars acquired on the Dionex system

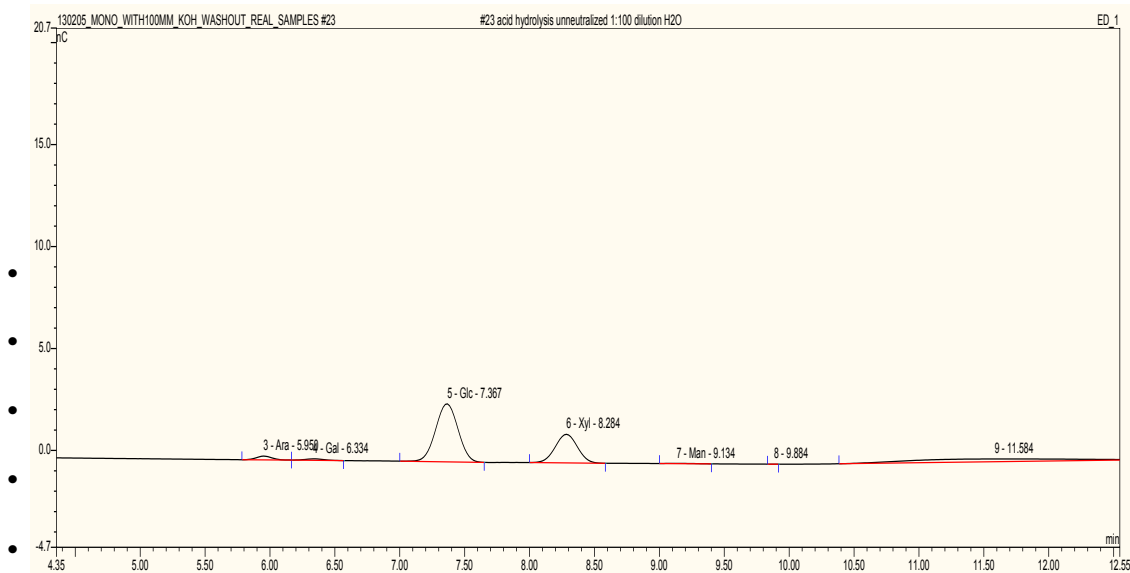


Figure 2B. Chromatogram of Switchgrass Cell Wall Carbohydrate Sample Acquired on Dionex System

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania (Akwasi Boateng)**
 - ✓ Manuscript in final stages of preparation on pyrolysis of biomass from stem tissue of 12 upland switchgrass genotypes developed by divergently breeding for differences in in vitro dry matter digestibility and with well-characterized differences in lignin concentration, biomass quality traits, and stem anatomy. The study was conducted to determine the effects of biomass composition on yields of products obtained in a pyrolyser. Yields for several groups of compounds were influenced by the presence or absence of a catalyst. In particular, acids were more prevalent in the absence of the catalyst, while aromatics were significantly enriched in the presence of the catalyst. Significant differences in the recovery of a number of phenolic compounds were attributable to the changes in cell wall composition and plant architecture in the plants analyzed. These differences in turn were the result of divergently breeding plants for ruminant digestibility. Overall, the results indicate that switchgrass germplasm can be bred for improved conversion in thermochemical platforms. Data will be presented at the SIMM meeting in late April 2013.
 - ✓ Additional pyrolysis and associated gas chromatography/mass spectrometry work was temporarily delayed until a set of biomass type lowland switchgrass samples were selected that could be used to test the effects of genetic differences in lignin and biomass ash content on pyrolysis product yields.

4. Explanation of Variance

Overall accomplishments exceeded goals. In the compositional analyses work, the soluble sugar analysis will need to be modified to be compatible with HPLC analysis. Pyrolysis work was temporarily delayed while a sample set was developed to test for the effects of genetic differences in both lignin and ash concentration of biomass from lowland, biomass type switchgrass on pyrolysis yields.

5. Plans for Next Quarter

- **Breeding & Genetics – ARS-Lincoln, NEBRASKA (Ken Vogel)**
 - ✓ Complete greenhouse crosses, clean and process seed from crosses.
 - ✓ Complete grinding of 2012 biomass samples. Complete 75% of NIRS scans. Complete NIRS prediction of samples from selection nurseries scheduled for completion in 2013.
 - ✓ Summarize first biomass mineral analysis study comparing methods and laboratories.
 - ✓ Complete early spring work on field nurseries.
 - ✓ Complete planned purchase of new NIRS unit and have laboratory technicians trained in its use.
- **Breeding and Genetics – ARS-Madison (Mike Casler)**
 - ✓ Complete establishment of 40K seedlings of switchgrass and big bluestem in greenhouse.
 - ✓ Submit switchgrass manuscript on 20 years of breeding for increased biomass yield.
 - ✓ Submit first set of parental genotypes to *Joint Genome Institute* for sequencing. Conduct fertilization, weed control, and soil sampling on all field studies in Wisconsin.
- **Compositional Analyses – ARS-Peoria (Bruce Dien)**
 - ✓ Finalize protocol for compositional analysis of neutral and acidic carbohydrates and Klason lignin and validate with calibration set.
 - ✓ Initiate analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash.
- **Pyrolysis – ARS- Wyndmoor (Akwasi Boateng)**

- ✓ Complete and submit for publication a manuscript on pyrolysis products from upland switchgrass genotypes differing in stem lignin concentration.
- ✓ Initiate py-GC/MS analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash concentration.
- **Entomology – University of Nebraska-Lincoln (Tiffany Heng-Moss)**
 - ✓ Collaborate with Drs. Vogel, Mitchell and Casler to develop insect sampling plans for year 2.
 - ✓ Begin sampling nurseries for insects and other arthropods in late May.
- **Plant Pathology – University of Nebraska-Lincoln (Gary Yuen)**
 - ✓ Determine presence of satellite PMV (SPMV) in samples from PMV-infected switchgrass plants.
 - ✓ SPMV is a separate virus species that can infect plants only in conjunction with PMV. Research with other plant species indicated that co-infection of the two viruses results in severe stunting.
 - ✓ Coordinate with other project personnel for a survey of multistate field experiments for diseases.
 - ✓ Analyze virus severity data collected from breeding nurseries to identify genotypes exhibiting lowest and highest levels of virus symptoms.
 - ✓ Continue efforts in pathogenicity testing of organisms isolated from switchgrass (i.e. organisms referenced above).

6. Publications, Presentations, and Proposals Submitted

- Bruce S. Dien, Patricia J. O'Bryan, , Michael D. Casler, Michael A. Cotta, Hans-Joachim G. Jung, JoAnn F.S. Lamb, Robert B. Mitchell, Gautam Sarath and Kenneth P. Vogel. "Variation in composition and yields among populations of alfalfa stems, reed canarygrass, and switchgrass for biochemical conversion to sugars and ethanol," 245th ACS National Meeting & Exposition, New Orleans, LA, April 7-11, 2013, [Accepted for oral presentation.]
- Gautam Sarath, Mark Hammer, Aaron Saathoff, Mullen, C., Akwasi Boateng, Robert B. Mitchell, Kenneth P. Vogel, and Scott Sattler. 2013. "Switchgrass, cell walls and pyrolysis 35th Symposium on Biotechnology for Fuels and Chemicals," Portland, OR. April 29-May2, 2013. (Abstract, oral presentation).

Objective 2. Sustainable Feedstock Production Systems

The Sustainable Feedstock Production Systems objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The overarching goal is to produce a quantitative assessment of the net energy balance of candidate systems and to optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land.

1. Planned Activities

- Much of the research planned for this quarter dealt with sample processing and planning for the next quarter. Nearly all planned research for this first quarter was completed on schedule.

2. Actual Accomplishments

- **Iowa State University**
 - ✓ **Armstrong System Plots.** Analysis of soil samples from the 128 1.2-m time zero soil cores from the system plots on the Armstrong Farm is making good progress. Analysis of approximately 30% of the total of 768 samples is complete. We anticipate completing these analyses by August 2013. Soil analyses include total C, total N, POM-C, EC, CEC, pH, aggregate stability, and bulk density. Analysis of fall 2013 surface soil samples for Mehlich 3 extractable nutrients and pH is completed.
 - ✓ Due to 2012 drought there was a poor stand establishment on bioenergy switchgrass plots planted with a nurse crop on the Armstrong System plots. The switchgrass plots will need to be replanted in 2013. We are waiting to hear from Rob Mitchell on the availability of seed. We are planning not to use a nurse crop in 2013 to avoid similar problems which might occur if the drought continues. Stand establishment on the LIHD and HILD plots in 2012 was also poor due to drought; however, these plots are anticipated to recover in 2013 assuming adequate moisture.
 - ✓ **Boyd Biochar Factor Plots.** Preliminary analysis of the 2012-grain and biomass yields from the biochar factor plots on the Boyd Farm is complete. Data for surface soil moisture content was measured 13 times during June and July of 2012 and infiltration measured on each of the Boyd plots has also been analyzed. Analysis of the fall 2013 soil samples for Mehlich 3, CEC and pH are complete. Total C and N have yet to be analyzed. Rivka Fidel, Ph.D. student, is gearing up to measure CO₂ and N₂O emissions on the Boyd biochar factor plots during the 2013 growing season.

- ✓ **Field 70/71 plots.** Biochar was successfully applied after the fall of 2012 after harvest. Soil samples were collected after harvest, but before the biochar application. Analysis of these samples is ongoing. Preliminary analysis of grain and biomass yields for 2012 is complete. Bioenergy alfalfa will be seeded on some of the plots in 2013.
- ✓ Catherine Bonin, a new post doc, has joined Emily Heaton's group and will be leading the plant research at the Systems site.
- **University of Illinois**
 - ✓ Preparing 2013-plot location for planting. Since the site was on fallow marginal land, weed pressure is expected to be heavy. The site was tilled in the fall and sprayed to control weeds.
 - ✓ Planning to collect spring stand count data on the 2012 plots to determine establishment success.
 - ✓ The comparison field trial of switchgrass, big bluestem, prairie cordgrass, and *Miscanthus x giganteus* was harvested on November 15, 2012. Harvested biomass was weighed in the field. Samples were collected and dry biomass of the sample was determined.
- **University of Minnesota - Factor analysis plots, Becker, MN.**
 - ✓ On October 30, 2012 we harvested the factor analysis plot at Becker, Minnesota. 12' x 3' swaths were cut using the Carter harvester and weighed in the field. We hand-harvested two 1/4-m subsamples from each feedstock plot (n=144 subsamples).
 - ✓ Weed pressure was high. We visually estimated grass content in each subsample, but could not easily separate grass from weeds. Samples were weighed, ground and sent to Nebraska for analysis.
 - ✓ The low diversity mix will likely need to be reseeded. We will estimate how much stock we have remaining and may need to request more seed if it is available. We believe the Bioenergy, 'Shawnee', 'Sunburst' and the polyculture (CRP mix) are well established.
 - ✓ Plans are in place for seeding an additional factor plot at Lamberton in 2013.
- **USDA-ARS, Lincoln**
 - ✓ Received 2012 samples from MN.

- ✓ We are working with Outreach and Extension Objective collaborator Sue Hawkins to complete and review extension material.
- ✓ We are working with Outreach and Extension Objective collaborator Pam Porter and Jeff Volenec to complete a fact sheet on establishing bioenergy demonstration sites.
- ✓ **Site Visits.** We made a site visit to Illinois to evaluate plots. We would like to visit all System, Factor, and Demo sites this spring.
 - Evaluate Iowa system plots in March 2013. We have discussed Iowa demonstration sites, but nothing has yet been scheduled.
- ✓ **Summer 2013 Establishment Field Day.** We have tentatively scheduled an establishment field day with Kevin Shinnars for this summer to showcase herbaceous perennial feedstock establishment.
- ✓ Completed frequency grids for distribution to the demonstration site coordinators.
- ✓ We are planning now for burning the 2012 demonstration sites in April 2013, and seeding the 2013 demonstration sites in April.
- ✓ Bioenergy switchgrass seed cleaning has been completed and testing is beginning. Seed is in short supply. Much of the seed will be needed for release this spring.
- ✓ Continuing to sample the Nebraska Systems Analysis plots at 30-d intervals (as conditions allow) to determine DM losses over winter.
- ✓ Post-frost establishment year biomass from the Systems Analysis plots averaged 3.4 tons/acre for switchgrass, 1.2 tons/acre for big bluestem, and 1.9 tons/acre for the low diversity mixtures. Average rainfed maize grain yield on the control plots was 102 bu/acre and we removed 1.4 tons/acre of corn stover.
- ✓ We are working with CenUSA collaborator Virginia Jin to prepare for GHG sampling in the Nebraska Systems Analysis plots throughout the 2013 growing season.
- ✓ Dr. Virginia Jin completed the analysis of the baseline soil samples from the Nebraska Systems Analysis plots (Figure 3. Baseline Soil Data – CenUSA System Analysis Plots located near Mead, NE). Soils were sampled on June 14, 2012 with a hydraulic soil corer from sampling locations selected based on soil electrical conductivity values determined by a soil EC survey conducted on April 4, 2012. Soil pH and EC measured for 1:10 soil: water ratio. Soil-test N based on 2M KCl extractions (1:10). Soil-test P based on Mehlich-3 extractions (1:10). Values shown are the average values of 12 cores per depth per plot (n=6 per A and B subplots).

within each large plot). Values are for soil concentrations only (per unit air-dried soil), though nutrients per unit area will likely show same trends because soil bulk densities did not vary significantly.

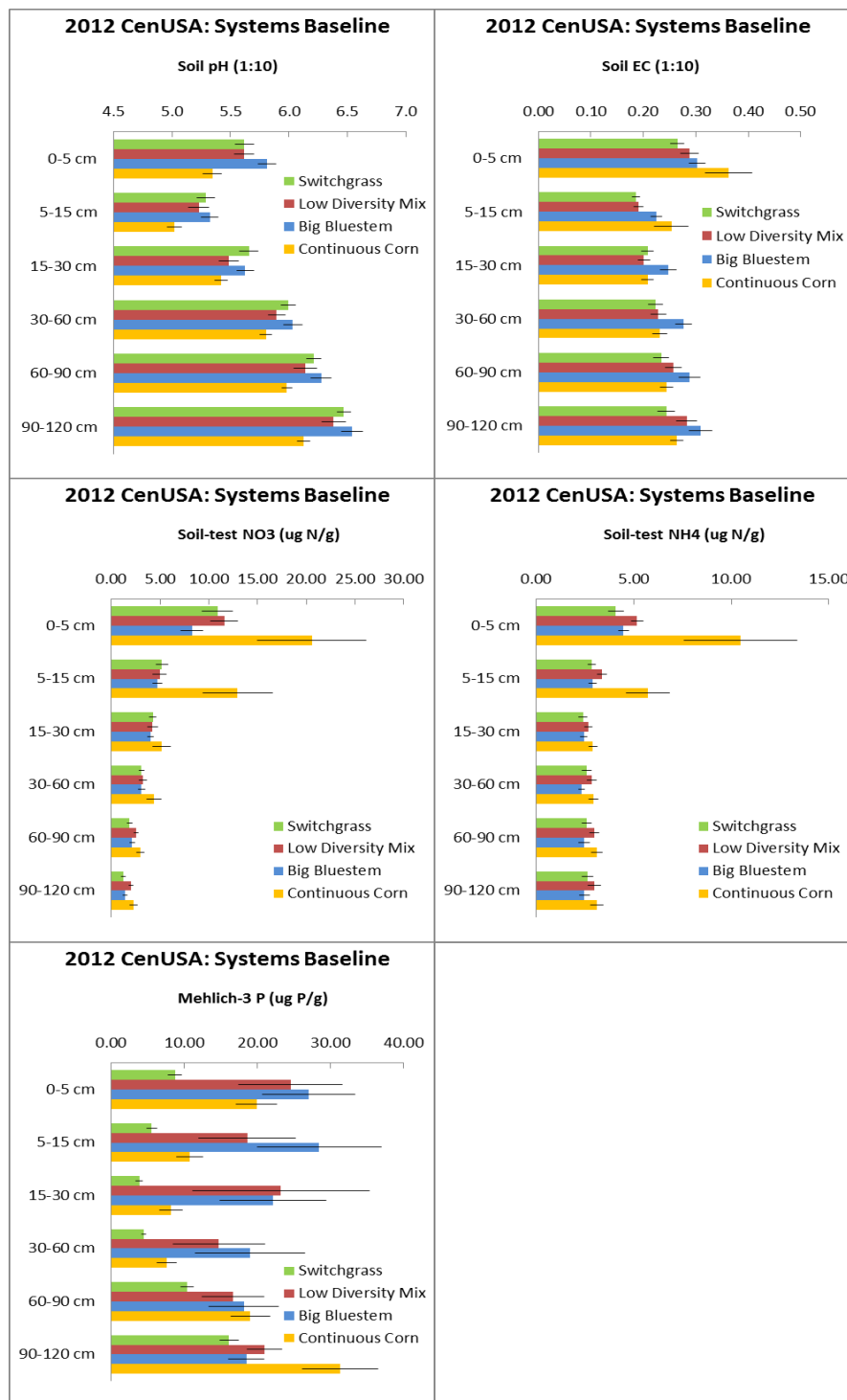


Figure 3. Baseline Soil Data – CenUSA System Analysis Plots located near Mead, NE

- ✓ Submitted lowland and upland switchgrass samples to CenUSA Advisory Board chair and ADM President for Research Tom Binder to evaluate their feedstock fractionation process. Fractions were returned to ARS-Lincoln for further analysis.
- ✓ Worked with CenUSA collaborators Deana Namuth-Covert and Amy Kohmetscher with assistance from Three Pillars Media to complete the CenUSA video, “Switchgrass Planting Practices for Stand Establishment” at the CenUSA Vimeo Channel (<https://vimeo.com/61137878>) and the CenUSA YouTube Channel (<http://youtu.be/vwBQ3aYpfmM>).
- **Purdue University**
 - ✓ All plant tissues from the factor-analysis plots at *Northeast Purdue Agricultural Center*, *Southeast Purdue Agricultural Center* and *Throckmorton Purdue Agricultural Center* and the systems analysis plots at the *Water Quality Field Station* have been dried and ground, and are ready for analysis.
 - ✓ Analysis has started on the following biomass attributes: total C and N; total ash; P and K; fiber, and non-structural carbohydrates.
 - ✓ Soil samples are dried and we are waiting for the arrival of a new soil grinder to expedite soil processing prior to analysis.
 - ✓ Greenhouse gas emission data from the *Systems Plots at the Water Quality Field Station* are becoming available. Note these data are preliminary and are not for publication/distribution beyond this report. Season-long means reveal that, while perennial biomass production systems may produce slightly more CO₂, they produce very little CH₄ and NO₂. Conventional grain cropping systems in the Midwest US serve as controls for these side-by-side comparisons. On average, these corn production systems emit nearly 50-times more NO₂ than the perennial biomass systems. Reminder: extremely dry weather occurred in summer 2012.
 - ✓ Biomass yield data is being summarized and analyzed statistically. Below are representative yield data from these analyses:
 - Biomass yield (kg dry matter/ha) of switchgrass (Shawnee) in 2012 as influenced by current nitrogen fertilizer rate and previous, long-term application of P and K fertilizer. Nitrogen had a modest impact on biomass yield. Potassium main effects were significant with a reduction in biomass observed with previous K application (8224 vs. 7865 kg/ha at 0 and 400 kg K/ha/yr, respectively). The main effect of previous P application was not significant. Reminder, extreme drought occurred at this location in Summer 2012.

Table 7. Previous K & P, kg/ha/yr				
	0 kg N/ha/yr	50 kg N/ha/yr	100 kg N/ha/yr	150 kg N/ha/yr
0 K/0 P	7932	8173	8846	8285
0 K/75 P	7628	7864	8818	8249
400 K/0 P	8084	7641	7520	7642
400 K/75 P	8054	8049	8018	7911
Mean	7924	7932	8300	8022

- Biomass yield (kg dry matter/ha) of *Miscanthus x g* in 2012 as influenced by nitrogen (N), phosphorus (P), and potassium (K) fertilizer rates. Nitrogen had a modest impact on biomass yield. The main effect of previous P application was not significant. Reminder, extreme drought occurred at this location in the summer of 2012.

Table 8. K & P, kg/ha/yr				
	0 kg N/ha/yr	50 kg N/ha/yr	100 kg N/ha/yr	150 kg N/ha/yr
0 K/0 P	15321	12843	12888	13310
400 K/75 P	15787	12307	14362	13174

- Biomass yield (kg dry matter/ha) of switchgrass (Shawnee) in 2012 as influenced by site quality in the context of phosphorus (P), and potassium (K) fertility. Maize and alfalfa yields were significantly reduced on the very low and low sites, and were high on the medium high and high sites. Switchgrass yields were unaffected by site quality defined in this manner in 2012. Reminder, extreme drought occurred at this location in summer 2012.
- For modeling biomass productivity in a landscape context, we have mapped all the marginal land areas in Indiana. We are setting up an APEX model to evaluate impacts of switchgrass and *Miscanthus* production of those marginal lands on hydrology (runoff volume, percolation), water quality (losses of sediment, N, and P) and biomass production. We have also set up a SWAT model in the Wabash River Watershed and White River Watershed to evaluate impacts of energy crop production on river water quality and quality. The model has been calibrated for stream flow. We are currently calibrating the model for measured sediment, N, and P concentrations and loads.

Table 9. Site productivity based on previous alfalfa and maize performance			
	Number of sites/plots	Biomass yield, kg/ha	Standard error of biomass yield, kg/ha
Very Low	3	8618	114
Low	20	8508	144
Medium Low	11	8298	304
Medium	17	8261	225
Medium High	18	8441	197
High	11	8600	183

3. Explanation of Variance

- All planned research is being conducted on schedule. Drought conditions prevented the harvest of some plots established in 2012 and some winter sampling was delayed by winter weather.

4. Plans for Next Quarter

- Due to drought, some stands planted in 2012 will be evaluated for re-planting.
- Plot residue will be removed by burning or mowing plots planted in 2012.
- New Factor and Demonstration plots will be planted at some locations as described in the original project plan.
- Otherwise, the activities for the upcoming quarter will proceed as originally described in the proposal.

5. Publications, Presentations, and Proposals Submitted

- Made two presentations to the *Missouri Certified Crop Advisors Workshop* (January 22, 2013), one presentation to the *North Central Weed Science Society*, two presentations to the *2012 Iowa Crop Management Conference*, one presentation to the *Heartland Regional Water Workshop*, and one presentation to the *Sun Grant Regional Feedstock Partnership* (February 15, 2013).

Objective 3. Feedstock Logistics

The Feedstock Logistics objective focuses on developing systems and strategies to enable sustainable and economic harvests, transportation and storage of feedstocks that meet

agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

1. Planned Activities – University of Wisconsin

Planned research activities included:

- Analysis of data collected in 2012;
- Management of the bale storage study;
- Development of machine configurations to combine cutting/intensive conditioning/tedding;
- Collection of post-storage size-reduction energy requirements of bales.

2. Actual Accomplishments – University of Wisconsin

We are statistically analyzing data from our work on bale aggregation, grass drying rate, and grass size-reduction. The analyzed data will serve as the basis for three papers that will be presented at the ASABE International Meeting in July 2013. Preparation of these manuscripts started during this period.

Bales were placed into storage in the fall of 2012 to investigate means to reduce DM losses from dry bales stored outdoors. Four treatments were considered in this dry bale study, including indoor and outdoor storage and bales wrapped in plastic film (either individually or in a tube). The bales have been monitored during the winter months to insure the study is progressing as planned. Bales will be removed from storage in early summer.

In 2012, we determined both intensive conditioning and wide-swath drying enhanced the drying rate of switchgrass. We have begun development of a machine configuration to combine cutting/intensive conditioning/tedding into a single operation. This system will involve a mower front-mounted on a tractor which will also pull a towed intensive conditioner equipped with a mounted tedder. We have arranged for loan of a tractor and mower to accomplish the first operations and are working to acquire the intensive conditioner and tedder. The system will be completed during the winter months and initial functional tests will be conducted using alfalfa and grasses in the summer before harvesting our perennial grasses in the fall.

We continue to quantify the energy required to size-reduce perennial grasses post-storage. Our work during the winter months have focused on improvements to our system of data collection, specifically the manner in which we determine the mass of material processed

during the time power and fuel use are quantified. Once our process is improved, we will collect data on the energy required to tub grind bales at various conditions. Specifically we will tub grind frozen bales and bales removed from storage during the spring thaw when they are damp.

Finally, we have rented 32 acres of marginal land in which we will establish a variety of perennial grasses. Ken Vogel, Rob Mitchell and Mike Casler are providing input on the type and variety of grasses we will establish in the spring. A grass establishment outreach field day is under consideration.

3. Explanation of Variance – University of Wisconsin

There were no variances – we accomplished all that we had planned during this period.

4. Plans for Next Quarter – University of Wisconsin

We plan to:

- Finish analyzing 2012 data and prepare manuscripts for the American Society of Agricultural and Biological Engineers meeting;
- Manage our bale storage study;
- Finish configuration of the combined cutting/intensive conditioning/tedding machine;
- Collect post-storage size-reduction energy requirements of bales removed from storage during and after outdoor winter storage;
- Harvest grasses that were over-wintered;
- Begin establishment of perennial grasses on rented acreage and potentially develop an outreach field day.

5. Publications, Presentations, and Proposals Submitted – University of Wisconsin

None to report this period.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis and Tools

This objective provides detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

We focus on four overarching tasks:

- **Task 1.** Adapt existing biophysical models to best represent data generated from field trials and other data sources;
- **Task 2.** Adapt existing economic land-use models to best represent cropping system production costs and returns;
- **Task 3.** Integrate physical and economic models to create spatially explicit simulation models representing a wide variety of biomass production options;
- **Task 4.** Evaluate the life cycle environmental consequences of various bioenergy landscapes.

1. Planned Activities

Iowa State University

The first two broad tasks under Objective 4 are to adapt existing biophysical models to best represent field trials and other data and to adapt existing economic land-use models to best represent cropping system production costs and returns.

University of Minnesota

Planned activities for this quarter include continued work on Task 1 and Task 2 and the initiation of Task 3.

2. Actual Accomplishments

Iowa State University

- We have received a new version of the EPIC model that features an entirely new soil carbon cycling submodel (along with the GHG emission algorithms). The decision to replace the existing soil carbon submodel, which was based on the methods used in the Century/DAYCENT models, was made by Dr. César Izaurralde (www.globalchange.umd.edu/staff/rizaurralde/) and colleagues to deal with persistent stability problems (which we noted in previous quarterly reports). We have noticed improved soil carbon results in initial testing of this code.
- We completed the draft of a policy brief that provides an assessment of the potential for cellulosic feedstocks to reduce the frequency and magnitude of flood events in the Raccoon River Watershed in Iowa. We use a watershed based hydrologic model to represent changes in water movement under different land uses in the watershed. First, we develop a baseline scenario of flood risk based on the current land use and typical weather patterns. We then simulate the effects of varying levels of increased perennials

on the landscape under the same weather patterns and compare the change in stream flows and water quality to the baseline scenario. A manuscript based on this paper is now completed, revisions have been invited and we are nearly ready for resubmission.

- We have begun work on a manuscript entitled “Optimal Placement of Second Generation Biofuels in a Watershed: Is Marginal Land the Answer?” for presentation at the annual meeting of the *Agricultural and Applied Economics Association*. This paper will address concern about competition between corn used for ethanol production and corn used for feed has led to the suggestion that second generation feed stocks, such as switchgrass and other perennial grasses, be restricted to low productivity “marginal” land to avoid food price effects of biofuel production. Although perennial grasses have promising environmental attributes related to GHG emissions, soil erosion, and water quality, the technology to cost effectively convert them to liquid fuels is still under development. Further, these feedstocks are bulky and there are likely to be large agglomeration economies by locating fields near each other. From an environmental perspective, the optimal location of switchgrass will likely depend on the topography of fields in a watershed, proximity to waterways and soil characteristics. We present a simple model of agricultural land use to study the efficiency tradeoffs associated with restricting switchgrass to marginal land vs. allowing it to be located where it would be most profitable or achieve the greatest water quality benefits. We consider these tradeoffs explicitly for the Raccoon River watershed.
- A major component of the ISU-CARD modeling work in this objective involves the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. There is now a much denser subwatershed delineation; e.g., 5,279 12-digit subwatersheds versus 131 8-digit subwatersheds for the UMRB. This modeling structure will provide the ability to perform enhanced scenarios including greatly refined targeting scenarios to study placement of switchgrass and other biofuel crops in the landscape to evaluate the water quality and carbon effects at the landscape level. Initial calibrations of the model are complete. We have moved into a phase of in-depth testing of the Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) SWAT models. At present, the focus is on using automatic calibration via the SWAT-CUP software (www.eawag.ch/forschung/siam/software/swat/index) using simpler model structures that are delineated with the 12-digit subwatersheds but with no HRUs (see <http://pubs.usgs.gov/tm/tm11a3/> for descriptions of 12-digit and other standard watershed classifications).

University of Minnesota

Our major accomplishment this quarter was finishing compilation of our switchgrass datasets and corn trial yields in our investigation of yield gaps. We began our initial analysis, which is revealing potentially large areas of improvement when commercializing production.

We received comments back from a journal on our comparison of U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. We have been working on a revision and will be resubmitting it in the current quarter.

Other ongoing projects include continued work on compiling production cost and return data for switchgrass, exploring different biodiversity models for use in our InVEST modeling, and writing of scripts to automate the modeling of biomass production placement on the landscape.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

Iowa State University

Continue work on the first two tasks:

- To adapt existing biophysical models to best represent field trials and other data, and
- To adapt existing economic land-use models to best represent cropping system production costs and returns.

We hope to have a draft of a paper studying the optimal placement of switchgrass with respect to both bioenergy and water quality goals completed by the summer of 2013.

University of Minnesota

Next quarter will include continued work on Tasks 1, 2, and 3, as well as continued work ahead of schedule on Task 4 (Evaluate the life cycle environmental consequences of various bioenergy landscapes).

5. Publications, Presentations, and Proposals Submitted

- Gonzalez-Ramirez, J., A. Valcu, and C. Kling. "An Overview of Carbon Offsets from Agriculture," Annual Review of Resource Economics 4 (2012): 145-160.

- Jason Hill. “Biofuels: Life cycle impacts on land and air” Workshop on the Nexus of Biofuels Energy, Climate Change, and Health. Institute of Medicine of the National Academies, Washington, DC, January 2013.
- Jason Hill. “Evaluating life cycle impacts of biomass production for bioproducts and bioenergy” Catalysis Center for Energy Innovation, Minneapolis, MN, January 2013.
- Jason Hill. “Green engineering – The future” The Society of Women Engineers Region H Conference, Minneapolis, MN, February 2013.
- Kling, C. National Science Foundation, “Climate and Human Dynamics as Amplifiers of Natural Change: A Framework for Vulnerability Assessment and Mitigation Planning, (Principal Investigator), 2012-2016, \$480,000.
- Markets and Regulation: Alternative or Complements, presentation to the 2012 Agricultural Outlook Forum, sponsored by USDA, Washington DC, February 2012, available on www.card.iastate.edu/environment/presentations.aspx.
- Rabotyagov, Sergey, Adriana Valcu, and Catherine L. Kling. “Reversing the Property Rights: Practice-Based Approaches for Controlling Agricultural Nonpoint-Source Water Pollution When Emissions Aggregate Nonlinearly” Presented at Global Environmental Challenges: The Role of China, Shanghai, China December 12-13, 2012.
- The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center, presentation, available at www.card.iastate.edu/environment/presentations.aspx.
- “Water Quality: Corn vs. Switchgrass,” Presented at the Roundtable on Environmental Health Sciences, Research, and Medicine “The Nexus of Biofuels Energy, Climate Change, and Health” Institute of Medicine, National Academy of Sciences, January 2013.

POST-HARVEST

Objective 5. Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels

The Feedstock Conversion and Refining Objective will perform a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Estimating energy efficiency, GHG emissions, capital costs, and operating costs of the proposed biomass-to-biofuels conversion system using technoeconomic analysis;
- Preparing and characterizing Biochar for agronomics evaluations.

Sub-objective 1. Perform Technoeconomic Analysis

1. Planned Activities

Conduct preliminary literature search to develop plans for process modeling assumptions. Determine most appropriate modeling program and begin model development.

2. Actual Accomplishments

Chemstation's Chemcad® has been selected as the process modeling software to be used. A literature review was completed and the base process model has been constructed as shown in Figure 1. This model contains provisions to simulate traditional fast pyrolysis or in-situ catalytic pyrolysis.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

Additional literature research must be conducted to refine yield assumptions in the process model. Initial yield results from micropyrolysis tests completed by Akwasi Boateng as part of the Feedstock Development Objective (Objective 1) will be compared to published data.

Publications, Presentations, and Proposals Submitted

None to report this period.

Sub-objective 2. Prepare and characterize biochar

1. Planned Activities

Laboratory work to analyze the anion exchange capacity of biochars that have aging in aqueous solutions under oxidizing conditions.

2. Actual Accomplishments

Analysis of anion exchange capacity (AEC) for aged biochars was completed. The analysis included chars made from alfalfa, cellulose and corn stover biomass pyrolyzed at 500 and 700°C with control, aluminum, and iron pretreatments. The analysis was done in triplicate, hence a total of 54 samples were analyzed. The results indicate AEC values ranging from 0 to nearly 200 mmol/kg, with higher AEC values for the 700°C biochars relative to the 500°C biochars and significant effects of the metal pretreatments. The

[illegible]

3. Explanation of Variance

4. Plans for Next Quarter

5. Publications, Presentations, and Proposals Submitted

Objective 6. Markets and Distribution

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successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers;
- Estimate threshold returns that make feasible biomass production for biofuels.

1. Planned Activities

Our team anticipated a total of five activities for the first quarter of the second year of the project.

- **2012 Integrated Crop Management Conference.** Deliver a session at the 2012 Integrated Crop Management Conference (2012 ICM) CenUSA Bioenergy Symposium, “Understanding the economics of a system of perennial grasses for bioenergy in the central U.S.” (Keri Jacobs, CenUSA Co-Pd).
- **2012 ICM Survey.** Report the findings of the survey administered during the 2012 ICM (Keri Jacobs).
- **Farm-level CRP data.** Continue to push forward progress on access to farm-level CRP data (Keri Jacobs).
- **Spatial model of biomass supply.** Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin, CenUSA Collaborator).
- **Interactions with Industry.** Interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Dermot Hayes, CenUSA Co-Pd).
- Model the aggregate supply curve for switchgrass, wheat straw, and corn stover (Dermot Hayes).

2. Actual Accomplishments

Each of our planned activities for Q1 Y2 has been addressed in some manner. Brief explanations for each are provided here.

- **2012 Integrated Crop Management Conference and Survey.** As a means of identifying the barriers and drivers of implementation of the biomass production system, our team arranged to participate in an Integrated Crop Management (ICM) extension series December 28—29, 2012. Through a collaborative effort with CenUSA participants Jill Euken, Chad Hart, Sorrel Brown, and Rob Mitchell, Keri Jacobs delivered a presentation on the expected costs, returns, and production details of switchgrass as a biomass stock in this Central US region.
- A survey was administered to session participants to gain feedback that will be used to inform our modeling efforts and the policy and market mechanisms necessary to make the system viable. The survey results have been integrated in a report which is available as Exhibit 6. Drivers and Barriers to Perennial Grass Production for Biofuels See Exhibit 7, *Adoption of Switchgrass Production Survey*).
- **Farm-level CRP data.** Our team proposed to the USDA that an MOU be established to permit access to micro-level CRP data for signups 27 through 40 (recent general and continuous signups). These data include parcel-specific information on a type of marginal land that may be used in the project's system. Parcel specific information will be used to develop expectations of switchgrass biomass cost estimates, yields, and expected production penalty of switchgrass relative to competing crops. Our team anticipates a delay of several months before these data will be available to us, if the USDA is able to make them available. There has been no advancement of this activity during this quarter.
- **Spatial model of biomass supply.** Previous studies of cost of production of switchgrass in the region have been collected and updated to provide the cost basis needed for producer decision making. These costs will be adjusted to reflect production costs on marginal cropland. Data from switchgrass yield trials was obtained from 683 trials in the upper Midwest to help identify expected yields and yield variance by agronomic area. The gross average yield was 6.8 Mg/ha, ranging from about 1 to 18 Mg/ha. Further analysis will estimate the effects of region, variety, weather, plot size, etc., on yields obtained. This analysis will be conducted in collaboration with Rob Mitchell and Ken Vogel who are working on objectives 1 (Feedstock development) and 2 (Sustainable feedstock production systems).

Results from nine recent surveys of producer willingness to contract for biomass production are being studied to obtain quantitative and qualitative information about factors affecting this willingness. This information and preliminary budget analyses will provide the basis for simple questionnaires to obtain more information from producer participants in project activities.

A spatial model of biomass supply with heterogeneous producers has been developed and empirically implemented to reveal how heterogeneity among agronomic circumstances and producer characteristics might affect the cost of securing sufficient quantities of feedstock. Preliminary results suggest that these sources of heterogeneity would increase delivered biomass costs by as much as 20%, an important consideration in evaluating the advantages of on-farm pyrolytic processing versus delivery of biomass to large-scale refining plants. Richard Perrin is collecting switchgrass trial data from states relevant to our study. We expect this will continue into the next quarter.

- **Modeling the aggregate supply curve for switchgrass, wheat straw, and corn stover.** Dermot Hayes continues to work on the regional supply curve for grasses and corn stover using a real options framework. This work will be expected to be ongoing through the year.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

During the third quarter of year 2, our team will work on the following activities:

- Continue to push forward progress on access to farm-level CRP data (Keri Jacobs).
- Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin).
- Continue to interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Dermot Hayes).
- Continue modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Dermot Hayes).

5. Publications, Presentations, and Proposals Submitted

- Keri Jacobs. “Understanding the economics of a system of perennial grasses for bioenergy in the Central United States,” Presentation at the Integrated Crop Management Conference, Ames, Iowa, November 28 - 29, 2012.

Objective 7. Health & Safety

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place.

The Health and Safety team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and
- The risks of air/dust exposure.

1. Task 1 – Managing Risks in Producing Feedstocks

a. Planned Activities

The team is expanding the collection of the various tasks and responsibilities associated with producing biofeedstocks more slowly now and has placed more focus upon the risk analysis of tasks than upon the identification of tasks. The major headings or grouping of tasks fall under these five areas:

1. Establishment
2. Maintaining
3. Harvest
4. On-site processing and storage
5. Transportation

The implementation of a risk assessment was begun with establishment tasks.

b. Actual Accomplishments

After first examining preliminary injury data sources for establishment tasks to be used in the risk assessment, a change in the procedure of measuring the risk was needed because of the lack of specific data required for analysis. As the production of biofeedstocks has a lack of specific data on injury causation during establishment of biofeedstock, emphasis is being placed on qualitative risk assessment techniques rather than quantitative ones. It is also apparent that the other major grouping of tasks (maintenance, harvest, etc.) will have similar issues with specific injury data. A comprehensive examination of risk assessment techniques is being conducted to determine the best approach to use for establishment, maintaining, harvest, on-site processing and storage, and transportation tasks of biofeedstock production.

Curtis Fielder, a new Ph.D. graduate student, joined our team. He will be working primarily on the risk analysis for tasks associated with producing biofeedstocks.

The team has also established a cooperative arrangement with Dennis Murphy the investigator at Penn State University who is also working with another biofuel CAP project to collaborate in developing a standard to assess risk in these types of tasks.⁵

c. Explanation of Variance

Different risk assessment methods (e.g., energy, job, deviation, or fault tree) are available. Each risk assessment method takes discrete tasks and looks through those tasks for potential danger to personnel and equipment involved in the task. Energy analysis looks at sources of energy within a system; looking for potential contacts of energy with personnel or equipment as hazards to be avoided.

Job and Work Safety Analysis. Job and work safety analysis looks at tasks undertaken by personnel looking for time and tasks during which injury may occur. Corrections to work plans are then made to minimize or eliminate tasks deemed dangerous. Deviation analysis starts with the assumption of a safe method of work and looks for deviations that can/do occur during that work. Once a deviation is identified a determination is made if it represents a potential hazard or a safer method of work.

Fault Tree. A fault tree works from an injury/hazardous event looking for all conditions and combinations of conditions that lead to that event. The best method for use would be determined by a review of results from representative tasks taken from different major grouping of tasks in biofeedstock production. For any of these methods to be effective, the tasks to be analyzed must be defined as clearly as possible, including any equipment or chemicals used for the task.

Since there is not a proven example of which risk analysis method works the best for these agricultural tasks, the team and collaborators at Penn State University both agree that is valuable to expend the time to correctly identify the standard risk method to use in biofeedstock production analysis. The development of a standard risk analysis method would better serve the industry than a series of different approaches applied to evaluating risk of tasks.

d. Plans for Next Quarter

⁵ Dennis Murphy Ph.D. is a Distinguished Professor of Agricultural and Biological Engineering Agricultural Safety and Health at Penn State University and an Extension Team Co-Chair for the Northeast Woody/Warm-season Biomass Consortium (AFRI-CAP) project (www.newbio.psu.edu)

Refinement of the accumulated listing of tasks and responsibilities will continue. Comparisons of risk assessments for handling the evaluation of the various tasks will be made with the expected outcome of determining the standard risk assessment tool to use for tasks in biofeedstock production.

e. Publications, Presentations, and Proposals Submitted

No new publication submitted this quarter.

Previous publication submitted: Schwab, C. V., and M. Hanna. 2012. Master Gardeners' safety precautions for handling, applying, and storing biochar. Cenusa bioenergy publication. ISU University Extension and Outreach, Ames, IA 50011.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities

The locations for dust exposures are compiled and those currently identified are being examined for determination of the most likely place to find the highest exposure rates. This will be the selection process to determine where the pilot analysis of actual dust exposure will take place.

b. Actual Accomplishments

The prioritized list locations for dust exposures were being developed and the primary location to be measured in Year 2 will be identified. The identification of the monitoring equipment needed to take dust samples was started.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

Needed monitoring equipment will be identified and obtained to conduct the pilot study. Approvals for human subjects and procedures will be established.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

OUTREACH AND EXTENSION

Objective 8. Education

The Education Objective seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks, as follow:

- To develop a shared bioenergy curriculum core for the Central Region
- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students

Subtask 1 is curriculum development. Subtask 2A is training undergraduates via an 8-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program. Subtask 2B is training graduate students via a 2-week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009. Subtask 2C is training graduate students via a monthly research webinar. The next portion of this report is broken into subtasks.

Subtask 1: Curriculum Development

1. Planned Activities

- **Module 2. Perennial Grass Establishment and Management**

Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review.

- **Module 3. Harvesting Systems for Bioenergy Grasses**

Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review.

- **Module 4. Storage Systems for Bioenergy Grasses**

Develop module content in PowerPoint and begin module development activities with Amy Kohmetscher (CenUSA Collaborator).

- **Module 5. Integrating Bioenergy Production into Current Systems**

Complete module development activities with Amy Kohmetscher.

- **Module 6. Markets and Distribution**

Complete development of content in PowerPoint and begin module development activities with Amy Kohmetscher.

- **Module 7 – Overview Module (lead author John Guretzky)**

Complete outline of remaining content.

2. Actual Accomplishments

We have made changes to the module format for ease in publishing the content.

- **Module 1. Perennial Grass Physiology, Growth, and Development.** Status of components (Lead author John Guretzky, CenUSA Collaborator).

The **Seedling Emergence** Activity has been accepted for publication in *Natural Science Education*.

- **Module 2. Perennial Grass Establishment and Management.** (Lead author John Guretzky)

- ✓ Initial internal review completed and edits made to the module.
- ✓ Edited and completed video demonstration on use of frequency grid to determine perennial grass establishment success. The video, How to Measure Stand Establishment Using a Grid, is available on the CenUSA website and on the CenUSA YouTube and Vimeo channels.⁶

- **Module 3. Perennial Grass Harvest Management.** (Lead authors Pat Murphy, CenUSA CoPd and Iman Beheshti Tabar)

- ✓ Content has been converted to an ADA compliant format.
- ✓ The edited content is ready for final internal review.

- **Module 4. Storage Management.** (Lead authors Pat Murphy and Iman Beheshti Tabar)

Completed outline of module content.

- **Module 5. Integrating Bioenergy Production into Current Systems.** (Lead author Nicole Olynk)

We are recording Camtasia lectures from PowerPoint slides.

- **Module 6. Markets & Distribution Module.** (Lead author Corrine Alexander)

We are recording Camtasia lectures from PowerPoint slides.

- **Module 7. Introduction to Perennial Grasses as a Bioenergy Feedstock.** (Lead author John Guretzky)

⁶ [www.cenusa.iastate.edu/Content/files/How to Measure Stand Establishment Using a Grid.mp4](http://www.cenusa.iastate.edu/Content/files/How_to_Measure_Stand_Establishment_Using_a_Grid.mp4); www.youtube.com/user/CenusaBioenergy; and <https://vimeo.com/cenusabioenergy>

Finished the conversion of the webinar into a lesson.

3. Explanation of Variance

Significant changes in the format of Module 3 needed to be made for ADA compliance prior to submitting the module for internal and external review. These changes have been made and will not affect the schedule, plan of work or budget.

4. Plans for Next Quarter

- **Module 3. Perennial Grass Harvest Management**

Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review

- **Module 4. Storage Management**

Continue module development activities with Amy Kohmetscher.

- **Module 5. Integrating Bioenergy Production into Current Systems**

Continue module development activities with Amy Kohmetscher.

- **Module 6. Markets & Distribution Module**

Continue module development activities with Amy Kohmetscher.

- **Module 8. Ecosystems Services for Dedicated Bioenergy Crops**

Begin outlining module content

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. Planned Activities

- Finish solicitation of projects from faculty.
- Promote the undergraduate internship program and encourage application submissions, working with lists of underrepresented minority students generated by ISU graduate college, lists of department chairs at relevant disciplines in universities across the Midwestern region, and through job-posting boards at regional institutions.
- Refresh content on website to reflect 2013 program and post 2013 application.

- Begin accepting applications and field inquiries about the program.

2. Actual Accomplishments

- Obtained research project descriptions from faculty.
- Promoted the undergraduate internship program to encourage application submissions as detailed above.
- Created detailed schedule for the 2013 undergraduate internship program.
- Website content updated with 2013 project and logistic information as well as new 2013 application.
- Applications are accepted and inquiries regarding the program are answered.
- Secured on-campus housing for students who will be hosted by Iowa State University faculty.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Continue to promote the undergraduate internship program and encourage application submissions through March 15, 2013 application deadline.
- Centrally vet and rank applicants based on letter of interest, academic achievement, previous research experience and letters of recommendation.
- Pool of likely candidates given to faculty hosts for review during week of March 18 with selection decisions by March 25.
- First offers to students on March 25, second offers to students on April 1 with cohort (11 students) finalized on April 15.
- Arrange travel for accepted students.
- Secure housing for students who will be placed with faculty mentors at partner institutions.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. Planned Activities

- Get tentative headcount from entire program.
- Finalize schedule.
- Get clear learning objectives for each day of content from program lead.
- Line up housing and facilities for program.

2. Actual Accomplishments

- Worked with central administrative staff and faculty to determine headcount for the program.
- Worked with faculty to create a ten-day schedule (June 9 – 19, 2013) for the intensive program at the Iowa State campus to include lectures, recitation periods, and field experiences covering each objective area.
- Reserved on-campus housing for graduate students and meeting rooms for the program delivery.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Determine final list of intensive program attendees.
- Provide faculty with full program agenda and details of each objective leaders' responsibilities for their portion of the intensive program.
- Arrange travel for graduate student participants and faculty presenters.

5. Publications, Presentations, and Proposals Submitted

None to report this period

Subtask 2C – Subtask 2C – Training Graduate Students via Monthly Research Webinar

1. Planned Activities

- Organize the first three research webinars.

- ✓ Objective 1 – February 22
- ✓ Objective 2 – March 29
- ✓ Objective 3 – April 25

2. Actual Accomplishments

- Held research webinar on February 22
 - ✓ *Twenty Years of Switchgrass Improvement to Create a Dedicated Bioenergy Crop* by Michael Casler.
 - ✓ *Genomic Selection to Improve Biomass Yield of Switchgrass* by graduate students Emily Rude and Guillaume Ramstein.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Deliver research webinars for Objective 2 -Sustainable Feedstock Production Systems and Objective 3 – Feedstock Logistics.
 - ✓ March 29 – Objective 2. Jeff Volenec, Rob Mitchell, and David Laird are working with their graduate students on content and delivery.
 - ✓ April 26 – Objective 3. Stuart Birrell and Kevin Shinnars are working with their graduate students on content and delivery.
- Begin organization of next three webinars (Objectives 4-6) to be delivered May – July 2013.

5. Publications, Presentations, and Proposals Submitted

- Guretzky, J., Kohmetscher, A. and Namuth-Covert, D. (2013) Grass Seed Structure and Seedling Emergence. Nat. Sci. Educ. 42:1-1 doi:10.4195/nse.2012.0018w.

Objective 9. Extension and Outreach

The Outreach and Extension Objective (Objective 9) serves as CenUSA's link to the larger community of agricultural and horticultural producers and the public-at-large. The team delivers science-based knowledge and informal education programs linked to CenUSA Objectives 1-7.

The following teams conduct the Outreach and Extension Objective's work:

- **Extension Staff Training/eXtension Team**

This team concentrates on creating and delivering professional development activities for Extension educators and agricultural and horticultural industry leaders.

- **Producer Research Plots/Perennial Grass Team**

This team covers the areas of:

- ✓ Production, harvest, storage, transportation;
- ✓ Social and community impacts;
- ✓ Producer and general public awareness of perennial crops and Biochar agriculture;
- ✓ Certified Crop Advisor training.

- **Economics and Decision Tools Team**

The Economics and Decision Tools Team will focus on the development of crop enterprise decision support tools to analyze the economic possibilities associated with converting acreage from existing conventional crops to energy biomass feedstock crops.

- **Health and Safety Team**

This team integrates its work with the Producer Research Plots/Perennial Grass and the Public Awareness/Horticulture/eXtension 4-H and Youth teams (See Objective 7. Health and Safety).

- **Public Awareness/Horticulture/eXtension/4-H and Youth Team**

This team focuses on two separate areas:

- **Youth Development.** The emphasis is on developing a series of experiential programs for youth that introduce the topics of biofuels production, carbon and nutrient cycling, and biochar as a soil amendment.
- **Broader Public Education/Master Gardener.** These programs acquaint the non-farm community with biofuels and biochar through a series of outreach activities using the Master Gardener volunteer model as the means of introducing the topics to the public.

▪ **Evaluation/Administration Team**

This team coordinates CenUSA's extensive extension and outreach activities. The team is also charged with developing evaluation mechanisms for assessing learning and behavior change resulting from extension and outreach activities, compiling evaluation results and preparing reports, and coordination of team meetings.

1. Extension Staff Training/eXtension Team

a. Planned Activities

To continue the review process for CenUSA articles, videos, and webinars so that they can be added to the CenUSA resource library and the eXtension web site.

b. Actual Accomplishments

Production of CenUSA Extension "on-line" learning articles hit stride this quarter. We are continuing the review process. Accomplishments include:

- Produced the extension fact sheet/article "Optimizing Harvest for Perennial Grasses" which is now available on the CenUSA website (www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=52)
- Finished review of article "Logistical Challenges to Switchgrass (*Panicum virgatum* L. as a Bioenergy Crop."
- Produced the video "Optimizing Harvest of Perennial Grasses for Biofuel. The video is available on the CenUSA web site, the CenUSA Vimeo Channel (<https://vimeo.com/57621501>) and the CenUSA YouTube Channel (<http://youtu.be/NMt5Ct-65-Y>).
- **CenUSA Video/Webinar Statistics.**
 - **Vimeo Channel.** During this quarter, the 22 CenUSA videos archived on Vimeo have had 65 plays, or users who viewed the video from the site. The 22 videos also had 4,370 loads. This means 4,370 saw the video, but did not play it. In addition, CenUSA videos were embedded on various web pages 3,205 times this quarter, meaning that people are sharing the CenUSA videos with others through their own pages.
 - 10 users downloaded a copy of a CenUSA video from the Vimeo site. This means the video was saved to their hard drive (users do this because they have limited Internet connectivity which does not allow for live streaming of a video. Once the

video is downloaded, it is available on their computer to watch at their convenience.

- All total this quarter, CenUSA web-based materials had 75 solid contacts and 7,395 people were exposed to the CenUSA project even though they did not explicitly view the video or webinar.

c. Explanation of Variance

The CenUSA Extension team for on-line learning articles, videos, and webinars underestimated the time required to receive reviews on articles and organize speakers for webinars. While the team was able to finish articles, only planning for webinars occurred. A webinar is scheduled for the third quarter of 2013. A video related to planting perennial grasses, while produced and edited, is still in need of a few final revisions.

While the articles created by the extension team are available on the CenUSA web site, eXtension requires a completely separate review process that we are working to coordinate. Once eXtension review is completed, the articles written in the second quarter will be available on the eXtension web site.

d. Plans for Next Quarter.

- Provide two CenUSA seminars at the First National Extension Energy Summit in Colorado April 29-May 1, 2013.
- Organize and plan for CenUSA and Iowa State University to host the Second National Extension Energy Summit in Iowa in 2014, and write and submit a grant application to NIFA for financial support for the summit (Jill Euken Co-Pd and Pam Porter, CenUSA Collaborator)
- Host a webinar for Extension Educators, producers, and industry professionals.
- Complete an extension article related to hydro-ecological and water quality benefits of perennial grasses.
- Finish reviewing the planting video and make it available to the public.
- Finish up eXtension reviews of articles and videos for posting on eXtension site.

e. Publications, Presentations, Proposals Submitted

2. Producer Research Plots/Perennial Grass Team

a. Planned Activities

- Recruit farmers for a second set of on-farm demonstration plots to be established in Indiana, Iowa, Nebraska, and Minnesota in the spring of 2013.
- Meet with the Minnesota Corn Growers Association to discuss CenUSA project objectives and the challenges associated with switchgrass establishment on marginal lands.
- Plan for field days to be held in June 2013 in Indiana and Iowa.
- Design a CenUSA Mini-series (four different CenUSA sessions) for the *Iowa Integrated Crop Management Conference* in December 2012.
- Work with the Purdue Exhibit Center to continue development of the CenUSA Bioenergy Grass exhibit.

b. Actual Accomplishments

- Farmers have been recruited for the second set of on-farm demonstration plots to be established in Indiana, Iowa, Nebraska, and Minnesota in 2013.
- Planning continues for June 2013 Indiana and Iowa field days.
- Four CenUSA sessions were held at the *Iowa Integrated Crop Management Conference*:
 - ✓ Chad Hart (CenUSA Collaborator) provided an outlook meeting for cropping production costs and expected returns, including information about pending nutrient management strategies and opportunities for perennial grasses for biofuel production. One hundred twenty farmers and agriculture industry leaders attended.
 - ✓ Kerri Jacobs hosted two sessions which were attended by 147 farmers and agriculture industry leaders. Jacobs provided an overview of the CenUSA vision and administered a survey to learn about their attitudes regarding production of perennial grasses for biofuels. See Exhibit 6 for survey results.
 - ✓ Rob Mitchell presented two sessions to a total of 56 people on the topic of perennial grass establishment.
 - ✓ David Laird (CenUSA CoPd) hosted two sessions, sharing current biochar research results with a total of 220 farmers and agriculture industry leaders.
- John Hay (CenUSA Collaborator) hosted sessions for 30 farmers at the *Nebraska Farm Machinery Show*.

- CenUSA Extension project personnel hosted a workshop for the *Indiana Biomass Energy Working Group* on the topic of the development of biofuels for the aviation industry. The working group is open to the public and is made up of diverse stakeholders from industry, government, trade organizations, universities, and entrepreneurs from throughout Indiana. The working group's goal is to create a climate in the state of Indiana that can foster the growth of a viable renewable energy industry, protect Indiana's environment, and provide energy security and green jobs in Indiana. CenUSA's goal in participating in this program was to educate participants about the research and prospects for the adoption of biofuels by the aviation industry. This could include the use of fuels derived from energy grasses related to the CenUSA project (See Exhibit 8. Possibilities for Aviation Biofuels in the Midwest).

There were 55 participants in the program (68% male, and 32% female). Thirty-two percent indicated they were "University faculty/staff", 24% "Extension Professionals," 20% of participants "Business Owners/Entrepreneurs", 16% "Non-Profit Organizations," and 8% "Government Employees. About 86% were between the ages of 25 and 45, 10% were over the age of 55, and 4% were aged 18 to 25.

Participants provided following information at the conclusion of the program.

- ✓ A strong majority of 57.7% stated they strongly agreed with the statement "The information provided me with new knowledge." 42.3% agreed with the statement, and 3.% disagreed.
- ✓ 46.2% of respondents strongly agreed, 50.0% agreed, and 3.8% disagreed with the statement "The new ideas presented will be helpful to me in my business."
- ✓ 26.1% strongly agreed, 65.2% agreed, 8.7% disagreed with the statement "The program provided me with new skills I would like to apply to my business."
- ✓ 29.2% strongly agreed, 62.5% agreed, 8.3% disagreed with the statement "The new skills will be useful in my business."
- ✓ **CenUSA Visual Display.** A new CenUSA visual display was rolled out at this event. The display was well received, with one participant representing the commercial aviation alternative fuels industry indicating he would like to see it exhibited at future aviation industry events.

The table top display included:

- Samples of switchgrass, big bluestem, and indiangrass seeds

- Plant material with biochar,
- A question and answer interactive display about the history, research, and future of bioenergy crop production, and
- Scrolling display units describing the CenUSA program.



Figure 5. CenUSA Bioenergy Visual Display (Vertical)

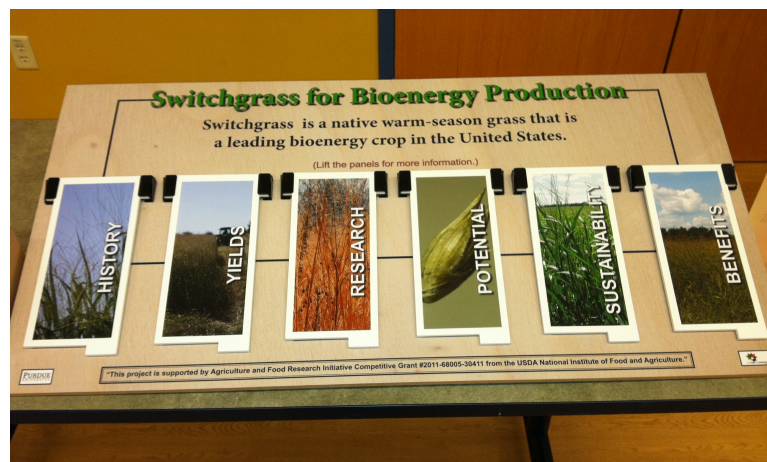


Figure 6. CenUSA Display

✓ CenUSA Bioenergy Extension Exhibit

- Samples of bioenergy grasses including switchgrass, big bluestem, and indiangrass.

- Box containing biochar and grass seed samples.
- Interactive Switchgrass information board.
- Dual scrolling display units addressing the “Why, Where, and What” context of bioenergy grass production along with benefits.
- Bob Wells and Jim Jensen (CenUSA Collaborators) included information about CenUSA in winter outlook meetings, meetings for women landowners and meetings for community service groups.
- c. Carl Rosen (CenUSA Collaborator) met with 60 Minnesota Corn Growers to discuss transitioning marginal land in Minnesota to perennial grasses for use in biofuel production. He detailed the CenUSA vision, use of grasses as a biomass crop to provide ecosystem services such as reduced runoff and maintenance of soil OM and structure.

d. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

e. Plans for Next Quarter

- **Purdue University**
 - ✓ Participate in the Purdue Extension sponsored *Small Farms Conference* on March 1-2, 2013. Keith Johnson (CenUSA Collaborator) will present CenUSA perennial grass information and we will host a CenUSA session on utilization of marginal crop and grass lands for energy crop production.
 - ✓ Visit Indiana FFA Center at Trafalgar to plan possibility of seeding plots and having an exhibit at the center.
 - ✓ Establish demonstration plots at Larry Pfug farm in Gibson County, Indiana.
 - ✓ Evaluate demonstration plots sown at the Jerry Sweeten farm in 2012 and the Throckmorton-Purdue Agricultural Center, and follow through with appropriate management.
 - ✓ Plan the June 21, 2013 forage tour. One of the tour stops will be at the CenUSA plots at the Sweeten farm.
 - ✓ Meet with Purdue University team members to keep apprised of results and to help in planning the CenUSA annual meeting.
 - ✓ Complete Extension publications started in previous quarter.

- **Nebraska CenUSA Extension**

- ✓ Make necessary preparations to burn CenUSA plot established in 2012.
- ✓ Burn plot in mid-March time frame.
- ✓ Assess emergence percentage of 2012 grass seedlings.
- ✓ Determine if reseeding/interseeding is required on 2012 plot. If needed, perform in mid-to-late April.
- ✓ Spray herbicide treatments.
- ✓ Locate second 2013 CenUSA plot site and secure usage agreement with the cooperator.
- ✓ Make preparations for 2013 seeding of second CenUSA Nebraska plot.
- ✓ Seed second CenUSA plot in mid-to-late April 2013.
- ✓ Spray herbicide treatments.

- **Iowa CenUSA Extension**

- ✓ Include information about CenUSA in three pasture walks and in 7 summer lease meetings.
- ✓ Burn 2012 on-farm demonstration plots, assess emergence, determine path forward (rescue or re-establish).
- ✓ Establish 2013 on-farm demonstration plot.

- **Minnesota CenUSA Extension**

- ✓ Burn the 2012 demonstration plots at Elko. Re-seed areas damaged in 2012 due to extreme rain events followed by extreme drought.
- ✓ Establish a second demonstration plot in Lamberton. These plots will be close to the Southwest Research and Outreach Center.
- ✓ Work with Southwest Research and Outreach Center to schedule field days once plots are established.

f. Publications, Presentations, Proposals Submitted

See previous section “Plans for Next Quarter.”

3. Economics and Decision Tools

Realizing heightened interest in mitigating the environmental impacts of row crop production in the Midwest, CenUSA has reached out to the Hypoxia Task Force co-Chair, Iowa Secretary of Agriculture Bill Northey (see: <http://water.epa.gov/type/watersheds/named/msbasin/index.cfm>) to discuss how CenUSA research, education and outreach (establishing perennial grasses on marginal lands and a distributed set of pyrolyzers to process the grass into biofuels and bioproducts) can be leveraged to support the Task Forces' goal of reducing and controlling hypoxia in the Gulf of Mexico.

Bill Lazarus, CenUSA Extension Economics team member, has developed the *Watershed Nitrogen Reduction Planning Tool (NBMP.xlsm) for Comparing the Economics of Practices to Reduce Watershed Nitrogen Loads*. This tool is being used to help states that drain into the Gulf evaluate if, where and how to use perennial grasses to mitigate nitrogen and phosphorus loads in the water (for additional information about the NBMP, see: http://faculty.apec.umn.edu/wlazarus/documents/nbmp_overview.pdf). This tool will be one of the resources discussed at a CenUSA-hosted workshop for the Hypoxia Task Force and environmental and agricultural groups in the fall of 2013.

4. Health and Safety

a. Planned Activities

Hire a graduate student to begin safety and hazards analysis.

b. Actual Accomplishments

Curtis Fielder enrolled in graduate school and was hired as graduate student for the CenUSA safety component.

c. Variance

No variance has been experienced and accomplishments are on schedule.

d. Publications, Presentations, Proposals Submitted

None to report this period.

5. Public Awareness/Horticulture/eXtension/4-H and Youth Team

1. Youth Development – Planned Activities

- Plan a 4-H science workshop to be held in Indiana in the summer of 2013.

- Develop e-learning modules for high school aged learners.
- Get biochar activities into second Indiana classroom at local middle school utilizing relationships established during the previous quarter.
- Complete youth Biofuel Fact Sheets.

2. Youth Development – Actual Accomplishments

- Biochar activities in two Lafayette, Indiana junior high school 8th grade science classrooms.
- Purdue biofuel fact sheets drafts are currently in final editing.
- Purdue started creating biofuel e-learning modules for high school aged students.
- Continued planning biofuel-related 4-H science workshops, including conference call between IN and Iowa CenUSA Extension youth teams.
- Iowa continued the development of the youth biochar curriculum.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- Complete the high school e-learning module working digital prototype.
- Meet with state FFA executive director to discuss plans for educational switchgrass test plot that could be utilized during FFA camps.
- Have digital prototype of e-learning module reviewed.
- Continue planning for the summer 4-H science workshop.
- Write up paperwork for summer 2013 intern.

5. Publications, Presentations, Proposals Submitted

Fact Sheets are in the editing stage.

3.B Broader Public Education/Master Gardener Program

a. Planned Activities

Provide CenUSA developed educational resources to Master Gardeners (MG), Junior Master Gardener (JMG) Leaders, and other community educators through local and state continuing education opportunities, such as State Master Gardener Conference and JMG training.

b. Actual Accomplishments

- **CenUSA Biochar Demonstration Gardens.** We compiled a comprehensive report covering the biochar gardens in the three Minnesota CenUSA Master Gardener sites (See Exhibit 8. 2012 CenUSA Biochar Demonstration Gardens (Minnesota)).
 - Julie Weisenhorn, Kurt Spokas, and Lynne Hagen (CenUSA Collaborator) met to go over draft of the 2012 biochar garden report.
- **New Biochar Garden Site.** Julie Weisenhorn secured a new biochar site near Lake Mille Lacs on the Fond du Lac Indian Reservation. Ground breaking will take place in 2013. Data from that site will be included with the other three sites in 2013.
 - Procured donation for additional biochar from Royal Oak Charcoal Company for the Lake Mille Lacs site.
- Collected “Ask an Expert” questions from the Master Gardener eXtension site; David Laird wrote responses to the questions and they are posted on the Master Gardener eXtension site.
- Summarized evaluation done at the Iowa CenUSA Master Gardener sites and drafted a Fact Sheet summarizing the data. The fact sheet will be completed during the third quarter.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

- Continue with the eXtension Master Gardener blog postings.
(<http://blogs.extension.org/mastergardener/tag/2012-cenusa-bioenergy-biochar-test-garden-research/>)
- Purchase seeds and locate a grower to start them.
- Recruit new project volunteers.
- Revamp data collection procedures and training materials for volunteers.

- Record Kurt Spokas (ARS) biochar presentation for training CenUSA Master Gardener volunteers and upon completion, schedule Minnesota volunteer training.
- Perform analytics on eXtension biochar blog.

e. Publications, Presentations, Proposals Submitted

- 2012 CenUSA Biochar Demonstration Gardens (Minnesota) (See Exhibit 8)
- “Ask an Expert” questions are currently under review by eXtension.

6. Evaluation and Administration

a. Planned Activities

- Continue to develop evaluation instruments and strategies for CenUSA Extension team members, and summaries of CenUSA data.
- Collect and assemble Outreach and Extension material for the CenUSA quarterly reports.

b. Actual Accomplishments

- Continue to develop evaluation instruments and strategies for CenUSA Extension team members, and summaries of CenUSA data.
- Plan and conduct a workshop for representatives of companies developing thermochemical processing technologies, CenUSA leaders, agricultural producer groups to develop a roadmap for commercializing thermochemical processing using herbaceous biomass produced in the Midwest.
- Collect and assemble Outreach and Extension material for the CenUSA quarterly reports.

c. Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter:

- Draft and submit grant application to NIFA to support the *Second Annual Extension Energy Summit* to be hosted by CenUSA and Iowa State University in 2014.
- Develop relationship with *Hypoxia Task Force*. (See Economics and Decision Tools, above).

- Assist Jason Hill (CenUSACo-Pd) with planning for the CenUSA Workshop with the *Hypoxia Task Force* and agricultural and environmental leaders. This workshop is tentatively set to be held in the fall of 2013.
- Continue evaluation efforts to document knowledge gained by participants in CenUSA Outreach and Extension activities.

e. Publications, Presentations, Proposals Submitted

See Fact Sheets referenced in sections above.



IOWA STATE UNIVERSITY

Bioeconomy Institute



Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Dates: December 11-12, 2012

Sponsors: ISU Bioeconomy Institute, CenUSA Bioenergy, USDA Central-East Regional Biomass Research Center, Iowa EPSCoR, Iowa Energy Center*

Location: Scheman Center, Iowa State University

December 11		
Time	Subject	Presenter(s)
11:30 am	Registration and Lunch	
12:15 pm	Welcome	<ul style="list-style-type: none"> • Wendy Wintersteen, Iowa State University • Jonathan Wickert, Iowa State University • Ken Moore, Iowa State University
12:30 pm	Sustainability Challenges to Biofuels	Byron Johnson, P66
1:00 pm	Thermochemical Conversion Technologies 101	Robert Brown, Iowa State University
1:30 pm	Impacts of Facility Scale and Location on Thermochemical Biorefinery Costs	Mark Wright, Iowa State University
2:00	Break	
2:15 pm	Ideal Feedstock Characteristics for Thermochemical Processing of Biomass <ul style="list-style-type: none"> • Pyrolysis • Acetic Acid Pulping • Solvent Liquefaction • Catalytic Pyrolysis • Gasification • Pyrolysis • Pyrolysis • Aqueous Phase Reforming & Catalytic Processing • Solvent Liquefaction 	<ul style="list-style-type: none"> • Mark Hughes, P66 • Tom Binder, ADM • Michelle Young, Chevron • Magdalena Ramirez, KiOR • Bert Bennett, ICM • Terry Marker, GTI • Stanley Frey, UOP • Andrew Held, Virent • Manuk Colakyan, Renmatix
3:45 pm	Q and A	
4:00 pm	Break	
4:15 pm	CenUSA USDA NIFA Bioenergy CAP Project Preparing the Midwest to Supply biomass Feedstocks for Thermochemical Processing	Ken Moore, Iowa State University

4:45 pm	Optimizing Plant Breeding, Agronomy, and Logistics for Thermochemical Processing <ul style="list-style-type: none"> • Perennial Grass Genetics • Perennial Grass Storage and Agronomics • Environmental and Genetic Bioenergy Traits in Corn Stover • Corn Stover Genetics • Corn Stover Agronomics 	<ul style="list-style-type: none"> • Ken Vogel, USDA ARS, Lincoln, NE • Rob Mitchell, USDA ARS, Lincoln, NE • Kendall Lamkey, Iowa State University • Thomas Lubberstedt, Iowa State University • Marty Schmer, USDA ARS, Lincoln, NE
5:45 pm	Q and A	
6:15 pm	Adjourn to ISU BioCentury Research Farm	Transportation provided
6:30 pm	Dinner	
7:15 pm	Tour	<ul style="list-style-type: none"> • Andy Suby, ISU, Overview • Stuart Birrell, ISU, Logistics • Robert Brown, ISU, Thermo Processing
7:45 pm	Dessert Buffet and Discussion	
8:15 pm	Adjourn Transportation to Scheman Parking Lot	Shuttle to Hotel

December 12		
Time	Subject	Presenter(s)
7:30 am	Breakfast	
8:00 am	Non-fuel Products from Thermochemical Processing <ul style="list-style-type: none"> • Heating Oil (30 min) • Biochar as a Soil Amendment (20 min) • Bioasphalt (20 min) 	<ul style="list-style-type: none"> • Prasad Gupte, DOE • David Laird, Iowa State University • Chris Williams, Iowa State University
9:15 am	Establishing Linkages Between Thermochemical Biorefiners and Midwest Biomass Feedstock Suppliers	<ul style="list-style-type: none"> • Brad Petersburg & Rusty Schmidt, Ag Ventures Alliance • Rod Backhaus & Howard Roe, Tall Corn Ethanol • Bill Couser, Lincolnway Energy • Paul Kenney, Kearney Area Ag Producers Alliance • Jeff Stroburg, West Central Coop • Rod Williamson, Iowa Corn Producer Assoc.
10:30 am	Q and A	
10:45 am	Break	
11:00 am	Assembling the Pieces to Commercialize Thermochemical Processing in the Midwest	All
12:00 pm	Lunch - Discussion Continues	
1:00 pm	Adjourn	

*Workshop support: Iowa State University Bioeconomy Institute; CenUSA Bioenergy, funded by USDA-Agriculture & Food Research Initiative Competitive Grant no. 2011-68005-30411 from USDA National Institute of Food & Agriculture ; Iowa EPSCoR, supported by the National Science Foundation under Grant Number EPS-1101284; & Iowa Energy Center. We also thank Ken Vogel, ARS for his assistance in developing this event.

Participants

Roadmap to Commercialize Thermochemical Biofuels and Bioproducts Processing in the Midwest Workshop

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INSTRUCTIONS - FACILITATED DISCUSSION

JILL EUKEN, FACILITATOR

DECEMBER 12, 2012

ASSEMBLING THE PIECES TO COMMERCIALIZE THERMOCHEMICAL PROCESSING IN THE MIDWEST

Vision	<ul style="list-style-type: none"> • The Midwest has commercial biorefineries using thermochemical technologies to convert perennial grasses, corn stover and other non-food biomass to biofuels and bioproducts.” <ul style="list-style-type: none"> ○ Participants suggest modifications to the vision statement
Knowledge	<ul style="list-style-type: none"> • “What have you learned at this workshop that has increased your confidence that thermochemical processing for biofuels and bioproducts will be commercialized in the Midwest?” (5 minutes) <ul style="list-style-type: none"> ○ Each participant responds to this statement on a 4x6 colored notecard <ul style="list-style-type: none"> - Notecards will be compiled on a PPT slide and projected during lunch
Recommendations	<ul style="list-style-type: none"> • “What specific action items would you recommend to speed commercialization of thermochemical processing in Midwest?” <ul style="list-style-type: none"> ○ Each participant writes 1 priority on a 5x8 white notecard. (5 minutes) ○ Participants at each table compare notecards and group similar answers together. Each table develops a concise description for the 2-3 groups of topics with the most notecards. The title(s)/description(s) are written in large print on 8 ½ X 11 paper (10 minutes) ○ Each table reports on their top 2-3 recommendations and posts them to the appropriate sticky wall column (Feedstock Development, Logistics, Processing Conversion, Marketing & Distribution, Workforce Development, Public & Policy Support, Other). Similar recommendations are aggregated. (10 minutes)
Reactions	<ul style="list-style-type: none"> • Participants react to recommendations <ul style="list-style-type: none"> ○ Each participant individually writes down: (multiples responses are o.k.): <ul style="list-style-type: none"> ✓ On a 5x 8 notecard, provide: Name of your company/organization/group and one thing your organization is <i>already working on</i> that is related to the recommendations on the sticky wall (Notecards will be collected and posted to the sticky wall). ✓ On a 5x 8 notecard, provide: Name of your company/organization/group and one thing your company name/organization/group <i>is positioned to address</i> regarding the recommendations and how your organization could move the needle on this recommendation (one recommendation/card) (Notecards will be collected and posted to the sticky wall). • The responses will be posted to the sticky wall for viewing during lunch and will be compiled and sent to all participants.

CenUSA Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Question: What specific action items would you recommend to speed commercialization of thermochemical processing in Midwest?

RECOMMENDATIONS

FEEDSTOCK DEVELOPMENT/LOGISTICS

- Vertical integration that identifies the specifics of the processes that need improvement.
- Focus on high value products that will allow the supply chain to develop/be understood.
- Education and communication between producers and industry so risks are understood and options can be developed to address risks.
- Create consortium, multi-industry, develop shared vision, R & D, etc. To be widely engaging of supply chain, stakeholders, and geographically diverse.

LOGISTICS

- Solve the feedstock supply chain for first plants
 - Densification?
 - Stabilization?
- Improve communication among stakeholders to build supply chains.

CONVERSION

- More R & D, demo plants with funding partnerships including government and industry.
- Long-term pre-commercial technology demonstrations of successful conversion.

PUBLIC & POLICY SUPPORT

- Long-term stable government policy.
- Develop policy, business climate and financial structures for construction of initial plants;
 - Incentives?

- State, region vs. national
- Develop regional strategy for thermochemical biofuels.
- Replace legislative uncertainty with national commitment.
- Long-term, stable renewable fuels policy (State and Federal).

REACTIONS TO RECOMMENDATIONS: ALREADY WORKING ON

FEEDSTOCK DEVELOPMENT

- Bryan Mellage – C-Minus
 - Bring value to by-product of thermochemical processing – biochar.
 - We will buy and sell biochar as carbon sequestration.
- USDA-ARS
 - Working to develop perennial grasses that yield 10 T/Acre.
- Iowa State University (Agronomy)
 - Develop sustainable biomass supply management systems
- Tom Binder – ADM
 - Developing pilot plant to take multiple feedstocks to value added products as well as fuels.
 - Hopefully successful without subsidies
 - We have worked with Monsanto, Deere, and consumer product companies to address value chain.
- USDA-ARS
 - Developing new improved varieties of feedstocks.
 - Developing sustainable production systems.
 - Developing tools to predict impact on ecosystem services.
- Iowa Corn Growers Association
 - We are supporting maintaining the RFS.

- We are funding research on thermochemical conversion to high value products.
- We are participating in research and meetings on feedstock harvest storage and transport.
- Jeff Volenec – Purdue – CenUSA
 - We are conducting research and education programs that will inform the production capabilities and environmental sustainability metrics of a wide range of biomass production systems. This information is needed for LCA, economic analysis, regulatory analysis, etc.
- USDA-ARS
 - Feedstock development
 - Feedstock production and logistics
 - Fuelshed-scale site selection for feedstock production
- Iowa State University (Extension)
 - Education potential producers and industry leaders on biomass production.
- UOP/Envergent
 - Advise on/work with feedstock requirements/constraints with the growers here in the Midwest.

FEEDSTOCK & LOGISTICS

- Chevron
 - Working with universities to better understand supply/logistics
- USDA-ARS (multi-locations and scientists)
 - Feedstock development
 - Feedstock quality
 - Feedstock quality assessment
 - Feedstock storage
 - Feedstock conversion

- Producer technology transfer
- Sustainability

LOGISTICS

- BP
 - Working with government and private industry to bring demo plants and other R & D on-line.
- USDA-ARS (multi-locations)
 - Provide feedstocks for testing – multi-types
 - CRADA's and other technology assistance

LOGISTICS/CONVERSION

- West Central
 - Develop a commercial scale model for collecting and storing biomass. (Prospective)
- UOP/Honeywell
 - Improve communications among stakeholders and build supply chains
 - We are in the petroleum business, but not operators. We are also in the renewables business. We have had to bring biorenewable feedstock suppliers together with fuels producers in the past to get projects to go.
- Iowa State University
 - Research on feedstock logistics
 - Research on thermochemical conversion
 - Research on sustainability
- Conversion
- Iowa State University (Agronomy)
 - Develop value added biochar technology
- Iowa State University

- R & D on thermochemical conversion
- Renmatix
 - Adopting our technology to process several of the feedstock discussed in the workshop.
- UOP/Honeywell
 - Building 1 tpd pilot plant to convert lignocellulosic biomass to gasoline and distillate fuels at Tesoro petroleum refinery in Hawaii.
- Andrew Held – Virent
 - Reduce technology risk and demonstrate cost performance such that strategic partners will invest and build production facilities.
- Chevron
 - Might build a demo unit to illustrate how different entities need to work together.
- Ag Ventures Alliance
 - We invested \$250K in Avello.
- Tom Binder – ADM
 - We are looking into conversions of hemicellulosic and lignin into multiple value added products and are able to interest large chemical companies.
- Iowa Energy Center
 - R & D/Pre-commercial and conversion technology development/demonstrations

WORKFORCE DEVELOPMENT/PUBLIC & POLICY SUPPORT

- West Central/REG
 - Have a dedicated staff working educating and advocating for stable public policy particularly as it related to RFS2.
- Iowa State University
 - ISU has several centers working on bioenergy related policy.

PUBLIC & POLICY SUPPORT/OTHER

- UOP/Envergent Technologies
 - Involvement in DOE projects to demonstrate the viability and economics of our process to further influence the adoption of policies that support its implementation.
- Farm Bureau
 - Already has policy that supports the continued development of renewable energy.

OTHER

- USDA-NIFA
 - Funding CenUSA
 - Provide post-award management support to facilitate a broadening consortium developing a shared vision among stakeholders across the entire supply chain and communities impacted by the development of regional systems.
 - Provide supplemental funding
 - Provide new funding for knowledge gaps identified
- Brad Petersburg – RDA & RDP
 - Using new markets tax credits to help finance the commercialization of one or more biorefineries in low-income communities.
- CenUSA
 - All areas with collaboration from USDA and industry partners.
- KiOR
 - Impact - Starting up commercial unit, results will affect the way stakeholders react in the future.
 - Positioning – Clear and focused strategy and development of IP platform.

REACTIONS TO RECOMMENDATIONS: POSITIONED TO ADDRESS

FEEDSTOCK DEVELOPMENT

- Iowa State University (Extension)

- Demonstrating to potential producers convincing risk management strategies to biomass production.
- Brad Petersburg – RDA and AgVA
 - Form producer groups to supply biomass and invest in biorefineries
- Iowa Corn Growers Association
 - Collaborate with companies that have thermochemical technology on research, demonstration, and supply chain.
 - Educate corn growers about future opportunities for markets for corn stover.
- Jeff Volenec (Purdue/CenUSA)
 - Initiate new research as needed – identified by stakeholders, to inform critical questions.
 - Participate in leadership/consortium of stakeholders discussions to move things forward.
- Bryan Mellage (SEN Energy)
 - Organize producers in Southeast Nebraska to get ready to bring a thermochemical plant to our area.
- USDA-ARS
 - May be able to reduce need for N fertilizer on perennial grasses.
- Unknown
 - Energy Grains – USDA grant to organize farmers to plant relationships that bring all into one.

FEEDSTOCK/LOGISTICS

- USDA-ARS
 - Feedstock densification and logistics.
- Unknown
 - Identify refiners that need that type of organization.

LOGISTICS

- Phillips 66
 - We want to become closer to growers, distributors, marketers, and public policy groups to better understand the supply chain for biomass to drop-in fuels.
- Unknown
 - POET's Project Liberty is demonstrating collection and stockpiling and logistics of corn stover.
- Ag Ventures Alliance
 - We could organize our farmers and have them sign long term supply contracts for corn stover at some determined price.
- Renmatix
 - Feedback to help with feedstock supply chain development

CONVERSION

- Iowa Energy Center
 - R & D, Pre-commercial conversion technology development, and demonstration
- Phillips 66
 - We are developing thermochemical technologies that produce drop-in fuels from biomass. These two technologies are currently in the pilot plant phase.

WORKFORCE DEVELOPMENT/PUBLIC & POLICY SUPPORT

- Iowa State University
 - Strategy for thermochemical biofuels
- Iowa State University
 - Participate in "industry" organization

PUBLIC & POLICY SUPPORT

- Iowa Economic Development Authority

- Working with private sector companies who are commercializing thermochemical-processing technologies.
- Future: develop financial incentives as new investment risk reduction tools specific to thermochemical technologies.
- Unknown
 - POET and many partners created Growth Energy, which is lobbying and public policy arm for industry renewable fuels.

PUBLIC & POLICY SUPPORT/OTHER

- Senator Tom Harkin (Alex Lynch)
 - Continuing to hold the line on RFS2 and ensure the success of the biofuels industry.
- BP
 - Could: lobby regulators for certainty regarding RFS2 regulations and goals.

OTHER

- Farm Bureau
 - May be able to assist with commercialization
- Howard Roe (Tall Corn)
 - POET is building a plant to handle corn stover in Emmetsburg; long-range plans are to build similar facilities at each plant (27).
- Unknown
 - Continue to work with Congress and the administration to create more stability in the industry.
- David Karson
 - Today: Student Guest
 - Future: Hopefully work on policy and financing in biofuel industry

WORKSHOP EVALUATION

CenUSA Bioenergy Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Dec. 11-12, 2012

1. What best describes your role?

- Researcher
- Biofuels producer
- Crop Grower Association Representative
- Government official
- Other

Researcher		Biofuels Producer		Crop Grower Association Rep.		Government Official		Other		Total	
14	41%	7	21%	2	6%	4	12%	7	21%	34	100%

2. What portion of this workshop did you attend?

- All or most
- About half
- Less than half

All or most		About half		Less than half		Total Response	
32	94%	1	3%	1	0%	34	100%

**3. Rate your understanding of ideal feedstock characteristics for thermochemical processing
BEFORE the workshop:**

- 1 – Little or none
- 2
- 3
- 4
- 5 – In-depth, expert

1 - Little or none		2		3		4		5 – In-depth, expert		Total Response		Average Rating
3	9%	8	24%	8	24%	8	24%	7	21%	34	100%	3.24

**4. Rate your understanding of ideal feedstock characteristics for thermochemical processing
AFTER attending the event:**

- 1 – No better
- 2
- 3 – Better
- 4
- 5 – Much better

1 – No better		2		3 - Better		4		5 – Much better		Total Response		Average Rating
2	6%	3	9%	11	32%	13	38%	5	15%	34	100%	3.47

5. Please rate the general technical content of the workshop.

- 1 – Too basic
- 2
- 3 – About right
- 4
- 5 – Too technical

1 – Too basic		2		3 – About right		4		5 – Too technical		Total Response		Average Rating
0	0%	2	6%	28	82%	4	12%	0	0%	34	100%	3.06

6. Please rate your opinion about the length of the workshop (approximately 1 day).

- 1 – Too short
- 2
- 3 – About right
- 4
- 5 – Too long

1 – Too short		2		3 – About right		4		5 – Too long		Total Response		Average Rating
0	0%	2	6%	30	88%	2	6%	0	0%	34	100%	3.00

Gender

- Male
- Female

Male		Female		Total	
27	82%	6	18%	33	97%

7. Ethnicity (check all that apply)

- Black or African American
- American Indian or Alaska native
- Asian
- Native Hawaiian or other Pacific Islander
- White
- Hispanic or Latino

Black or African American		American Indian or Alaska native		Asian		Native Hawaiian or other Pacific Islander		White		Hispanic or Latino		Total	
0	0%	0	0%	0	0%	0	0%	31	94%	2	6%	33	97%

Comments

- Really long last day, maybe a break before dinner
- Suggest ISU and CenUSA get a couple more social scientists involved on people side for “quantitative sociology” (e.g. Carmen Bain)
- Helped greatly
- I would have liked the presentation from the producers (2:15 pm Tuesday session) to have been longer by one more hour so that they could have talked a bit more about their company
- Great workshop, Thanks!
- Good program on topic, maybe more on technoeconomic analysis of processes

ERIC S. ZACH

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Lincoln, NE 68503

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Phone: (402) 471-5449

PROFILE

Wildlife Biologist possessing 15 years of experience with wildlife management methods, principles, and concepts in a variety of governmental and non-governmental organizations. My work experiences reflect a demonstrated competence working with the public as well as multi-disciplined partners on a variety of natural resource issues.

PROFESSIONAL EXPERIENCE

- **Ag Program Manager**, Nebraska Game and Parks Commission (2011-present)
 - Ag policy and program analysis, legislative contact, Association of Fish and Wildlife Agencies Bioenergy Working Group Chair, Central Basins Conservation Reserve Enhancement Program Coordinator
- **Highway Environmental Biologist**, Nebraska Department of Roads (2006-2011)
 - Endangered Species Act consultation for transportation projects, interagency team lead, technical assistance to field staff, wildlife monitoring
- **Fish and Wildlife Biologist**, Nebraska Game and Parks Commission (2003-2006)
 - Habitat management and manipulation on publicly owned lands, prescribed burn boss, community outreach, stakeholder relations, wildlife population monitoring
- **Wildlife Biologist**, Pheasants Forever (2002-2003)
 - Implement federal and state conservation programs with private landowners, interface with federal, state, and non-governmental organizations
- **Wildlife Specialist**, USDA-APHIS-Wildlife Services (2001-2002)
 - Wildlife management for the protection of human health and safety in aviation
- **Wildlife Technician**, Nebraska Game and Parks Commission (1997-2001)
 - Habitat management and manipulation, wildlife population monitoring

PROFESSIONAL CERTIFICATIONS

- Nebraska Water Leaders Academy Graduate 2013
- Interagency Consultation for Endangered Species
- S130/S190 Wildland Firefighter Certified (expired)
- Certified Pesticide Applicator
- Certified Erosion Control Designer and Inspector

EDUCATION

University of Nebraska-Lincoln	December 1998
BS in Natural Resource Sciences	
Major: Forestry, Fisheries, and Wildlife	Minor: Biological Sciences

INTERESTS

- Pheasants Forever member and volunteer
- Exec Board Member and Programs Committee Chair for The Wildlife Society-NE chapter
- Ducks Unlimited member
- Nebraska Sportsmen's Council

Drivers & Barriers to Perennial Grass Production for Biofuels

Keri Jacobs, PhD
Assistant Professor
Iowa State University Extension
kljacobs@iastate.edu



March 2013

Exhibit 6

The CenUSA vision is to create a regional system for producing biofuels from perennial grasses grown on land unsuitable or marginal for row crop production, while improving the sustainability of existing cropping systems through biomass crops that reduce runoff of agricultural nutrients and increase soil carbon sequestration.

At Iowa State University's 2012 Integrated Crop Management Conference, participants who attended a session on "Understanding the Economics of a System of Perennial Grasses for Bioenergy in the Central United States" learned about research in the expected costs and returns of perennial grass production, storage, harvest and transport. A follow-up survey measured their perceptions of establishing a switchgrass production system.

They were asked to rank both positive and negative aspects of or influences on a producer's decision to adopt switchgrass production. Results showed that respondents viewed the two **most important or most influential reasons to adopt** switchgrass production were:

- the opportunity to engage in an emerging market opportunity, and
- the conservation and habitat benefits of perennial grasses.

They identified the biggest barrier at this time is the lack of a current market for harvested grasses.

CenUSA researchers continue to discover and quantify the costs and returns to perennial grass production under different production and

technology scenarios with varying amounts of inputs and on varying qualities of land. The information presented to session participants illustrated that perennial grass production can compete with returns to traditional row crop or hay production under specific conditions.

Generally, participants who responded to "*What marketing, contracting, or policy mechanisms would need to be available in order for you to consider switchgrass production on land you manage?*" indicated they would need:

- a Biomass Crop Assistance Program or something similar,
- government funding of an insurance or risk management product, or
- a minimum price guarantee with a contract.

Feedback from participants showed that producers and farm managers will decide whether or not to adopt a perennial grass crop based on the economics of the system. Perennial grass production must be shown to be economically feasible in their enterprises. At the same time, responses indicated a willingness to take into account the non-market benefits (i.e. environmental advantages and benefits from energy independence).

Risk will play a large role in the adoption decision. Even if perennial grass production can be shown to be economically feasible, producers want the guarantee of a market and price for their production.

Learn more at <http://www.cenusa.iastate.edu>.

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

... and justice for all

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Adoption of Switchgrass Production Survey

2012 Integrated Crop Management Conference

November 28 – 29, 2012

Iowa State University Extension and Outreach

Dear ICM participant,

Thank you for attending the session on economics of a perennial grass system. The purpose of the session was to provide producers and farm managers with information regarding switchgrass production decisions and the expected costs and returns of a perennial grass system based on the best information we have today. This survey's purpose is to get feedback on your perceptions of the system.

You may skip questions you are not comfortable answering, and your responses cannot be linked to you in any way; responses are combined for all session. Please be sure to consider questions on the back of this page.

Thank you for participating in the session and taking time to respond to the survey. Feedback from our producers and farm managers is invaluable in directing our project's focus and thrust going forward.

Keri Jacobs

Assistant Professor and Extension Specialist, Dept of Economics

Iowa State University

1. An important objective of our project is to understand the barriers and drivers—from the perspective of producers and farm managers—of switchgrass production within the current landscape.
 - a. Rank the following drivers (positive aspects) of switchgrass production from most important to you or likely to influence your decision (1) to least important to you or likely (8) to influence your decision based on your own situation.
 - _____ enterprise diversification strategy
 - _____ conservation / habitat provision
 - _____ “get ahead of” environmental regulations
 - _____ opportunity to reduce nutrient usage
 - _____ emerging market opportunities
 - _____ longer term crop rotation strategy
 - _____ support and information from university extension
 - _____ other (please specify) _____

** Please briefly explain your top (1) ranking. Why is this most important in your opinion?

- b. Rank the following barriers (negative aspects) to switchgrass production from most important to you or likely to influence your decision (1) to least important to you or likely (8) to influence your decision based on your own situation.

_____ requires learning/adjusting to new production technologies

_____ additional machinery requirements / capital expenditures

_____ lack of current market / concerns over development of market

_____ may reduce CRP lands

_____ longer term crop rotation

_____ two-year crop establishment

_____ uncertainty of production due to leasing land

_____ other (please specify) _____

** Please briefly explain your top (1) ranking. Why is this most important in your opinion?

2. Would the returns to switchgrass production on marginal land need to be on-par with returns to corn/beans on that same land in order to consider producing switchgrass instead of corn/beans? If not, what other factors would you consider?

3. What marketing or contracting mechanisms would need to be available in order for you to consider switchgrass production? One example might be guaranteed price contracts.

4. Please provide the following information. Remember, your responses cannot not be linked back to you, but this information will be useful in identifying

a. Gender: _____ Male _____ Female

b. Age: _____ < 25 yrs _____ 25 – 34 yrs _____ 35 – 44 yrs
_____ 45 – 54 yrs _____ 55 – 64 yrs _____ > 65 yrs

c. How many acres do you control (make production decision for)? _____

d. Approximately what percent of these acres is classified as highly erodible (HEL)? _____%

e. What is your primary role in the operation?

_____ Producer _____ Professional Farm Manager

_____ Other (please specify) _____

Possibilities for Aviation Biofuels in the Midwest

Chad Martin, PhD
Keith Johnson, PhD
Patrick Murphy, PhD
Purdue University



January 2013

Exhibit 8

An educational meeting for stakeholders in biofuels production was held to showcase research being done on biofuels and their prospect for adoption by the aviation industry. The prospect could include the use of fuels derived from bioenergy grasses that are being studied by the CENUSA project, a 7-state effort among Midwest land-grant universities who are exploring the use of perennial energy grasses for biofuels. The meeting was sponsored by the Indiana Biomass Energy Working Group (see sidebar).

Participants (N=55) were surveyed after the program to measure the value of the information presented. Respondents (n=48) indicated the following:

- Information presented was current as far as I know: 100% strongly agree/agree
- Visuals and handouts were easily understood and helpful: 96.2% strongly agree/agree
- The information provided me with new knowledge: 100% strongly agree/agree
- The new ideas presented will be helpful to me in my business: 96.2% strongly agree/agree
- The program provided me with new skills I would like to apply to my business: 91.3% strongly agree/agree
- The new skills will be useful in my business: 91.7% strongly agree/agree

The demographics of participants represented:

- 68% male
- 32% female
- 20% business owners/entrepreneurs
- 16% non-profit organizations
- 32% university faculty/staff
- 24% Extension professionals
- 8% government employees
- 86% between ages of 25 and 45
- 4% between ages of 18 to 25
- 10% over the age of 55

A new CenUSA exhibit (see photos below) was rolled out at the event that included:

- a table top display with samples of switchgrass, big bluestem, and indiangrass seeds and plant material with biochar,
- a question and answer interactive display about the history, research, and future of bioenergy crop production, and
- scrolling displays describing the CENUSA program.

The exhibit got a lot of attention. An opportunity to expand the reach of biofuels research being done by CenUSA came when a participant representing the commercial aviation alternative fuels industry suggested it be displayed at future aviation industry events.

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

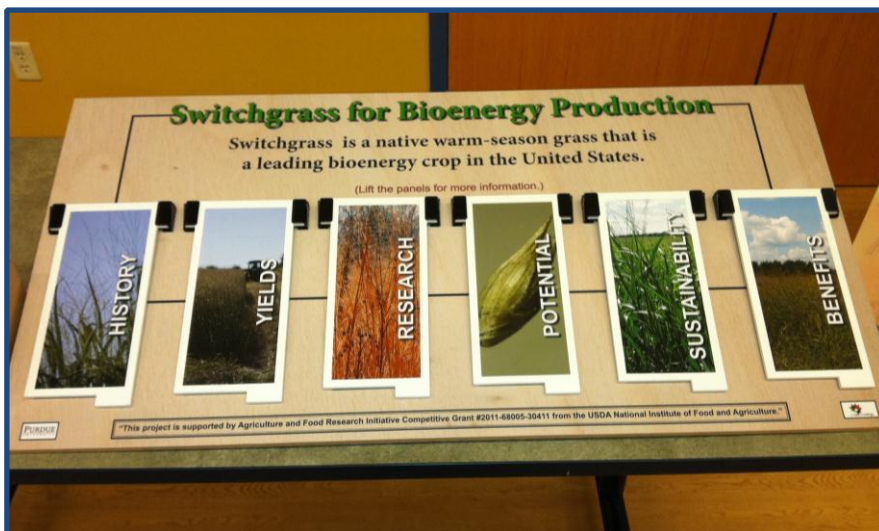
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CENUSA Bioenergy Extension Exhibit

- Samples of bioenergy grasses including switchgrass, big bluestem, and indiangrass
- Box containing biochar and grass seed samples
- Interactive switchgrass information board
- Dual scrolling display units addressing the “Why, Where, and What” context of bioenergy grass production along with benefits



Indiana Biomass Energy Working Group:

This group is open to the public and is made up of diverse stakeholders in the bioenergy industry, government, trade organizations, universities, and entrepreneurs from throughout Indiana. Their goals are:

- to create a climate in the state of Indiana that fosters the growth of a viable renewable energy industry, protect our environment, and
- provide energy security and green jobs in our communities.

2012 CenUSA Biochar Demonstration Gardens

IS BIOCHAR A GOOD SOIL AMENDMENT FOR GROWING VEGETABLES AND FLOWERS?

To answer this question, University of Minnesota Extension Master Gardeners and Iowa State Master Gardeners will test the productivity of vegetable and flower gardens amended with biochar at three Minnesota sites and three sites in Iowa from 2012-2015.



Extension Master Gardener volunteers have been invited to participate on the Extension and Outreach objective of a five-year national multi-state/university research project funded by the USDA National Institute for Food and Agriculture which is part of an initiative by the United States to lessen our dependence on foreign oil, to reduce greenhouse gas emission and to increase local renewable energy. Information about the project can be found at <http://www.cenusa.iastate.edu/>.

The goal for the Master Gardeners is to develop demonstration gardens amended with biochar and to collect data to determine any positive or negative effects of biochar on typical garden plants such as flowers and vegetables. The approach has been to replicate the home garden experience and techniques. Soil is amended per soil test results. Plants selected are typical home garden choices that are available commercially, and are evaluated by volunteers according to seed packet and catalog information. Gardening practices are those that would typically be employed in a home garden site.

This report reflects the results from the introductory year of 2012 in Minnesota.

SITE ESTABLISHMENT

Three sites in Minnesota and three sites in Iowa were established. Each site was designed to be identical. It was important to have the same varieties and numbers of plants in each location in order to draw

Author
Lynne Hagen

University of Minnesota
Extension

Cenusa Bioenergy, a USDA-funded research initiative, is investigating the creation of a sustainable Midwestern biofuels system.

Research Partners

Iowa State University—Lead
USDA Agricultural Research
Service (ARS)

Purdue University
University of Illinois
University of Minnesota
University of Nebraska—
Lincoln

University of Vermont
University of Wisconsin

www.cenusa.iastate.edu

a comparison across crops on data collected. All of the gardens are 1000 sq ft and each site was divided into three plots of 300 sq ft.

Each site has a Control (CTRL) plot with no biochar added; a Treatment 1 (TRT1) plot amended with one-half pound of biochar per square foot (150 pounds), and a Treatment 2 plot (TRT2) amended with one pound of biochar per square foot (300 pounds). Application was done by opening bags and dragging each over the garden site and then tilling it into the soil. Protective eyewear and clothing, gloves and a dust mask were worn by the applicators.

The soil structure in each site is uniquely different and it was anticipated that the results in each location would be quite different. Soil tests were also conducted at each site and the gardens were amended with fertilizer-only based on the recommendations of the soil tests.



Planting day at Arboretum site

Minnesota Landscape Arboretum, 3675 Arboretum Drive, Chaska, MN 55318

The Minnesota Landscape Arboretum (ARB) was selected as a site for this project because of its reputation as a world-class arboretum that is visited by over a quarter million visitors per year. With that amount of visibility, we believed it would be a great location to showcase this research project. The biochar research garden was established on the three-mile drive next to the Dahlia Trial Gardens.

The site was amended from a previously mowed turf area. The Arboretum staff prepped the site by removing the sod and tilling the soil to loosen it. Before the site could be planted, Extension Master Gardener volunteers installed deer proof fencing. Once the fence was completed, the soil was amended with biochar and fertilizer on May 18th three day prior to planting.

The soil at this location at the Arboretum is loamy clay. The soil test analysis showed a recommendation for a nitrogen-only fertilizer with a ratio of 23-0-0.

Watering at this site became labor intensive over the course of the season. A hook-up to an irrigation system was not an option, but the volunteers were able to run a hose to a sprinkler. That meant there needed to be a Master Gardener volunteer team to just monitor the moisture closely throughout the summer. In 2012 the season brought a lot of rain early in the season, but that changed later in the season when drought conditions set in.

The CenUSA Biochar plots were a featured site of the Arboretum's "Dig It" exhibition in 2012.

St. Paul Campus, intersection of Folwell and Gortner Avenues, St. Paul, MN 55108

The biochar garden at the St. Paul Campus (SPC), another great location, is in close proximity to the **University of Minnesota Display and Trial Gardens** and is visited regularly by students, staff, faculty and visitors.

The site was a former low-mow turf trial plot. The soil at this site is clay-loam. The sod was not removed but instead was tilled into the soil. The area where the garden is located is irrigated regularly. Planting day was challenging due to the wet clay and turf clods. The soil test in this garden recommended a nitrogen only fertilizer of 23-0-0, the same as the Arboretum site. Deer are not a problem at this site, but rabbits are, so a short fence was installed.



Planting day at St. Paul Campus site



Andover site before renovation

Bunker Hills Park, Bunker Hills Activities Center, 550 Bunker Lake Blvd NW, Andover, MN 55304

The Andover (AND) site was a last minute surprise and a very exciting prospect. We originally had a site selected at UMore Park in Dakota County. A new gravel mining operation expanded in that area and there was uncertainty about whether the biochar research garden could remain in the same location for four years.

The Anoka County Bunker Hills Park in Andover became a viable alternative. The Anoka County Parks and Recreation department staff was more than willing to accommodate the needs of the project. Not only did they clear out an existing area

of small trees and underbrush, they also enhanced their irrigation system to allow a hose and sprinkler to be set up on a timer. The park's staff also proved a couple of loads of mulch to help complete enhance the project. Since this garden is in a large suburban park, a deer proof fence needed to be constructed there as well.

The soil in this site is sandy, coarse texture, so it is a good site to test the theories of biochar being a benefit in poor or depleted soils. The soil test recommended a well-rounded fertilizer with a 10-10-10 ratio.

One variable in this garden, that presumably will affect the research, and that isn't present in the other sites, is that one end of the garden gets shade in the morning hours, but full sun the rest of the day.

Because of this, moisture is present in the soil longer during the day and the shady end also does not get the same amount of heat stress.

All of the gardens were amended with biochar prior to planting and were planted on May 21, 22 and 23rd.

THE VOLUNTEERS

“The University of Minnesota Extension Master Gardener program is an internationally recognized volunteer program. It exists in all fifty states, in Canada and in the United Kingdom. Nationally, there are nearly 100,000 Master Gardener volunteers from all walks of life. They reach about 5 million people each year – the equivalent of more than \$100 million in value to communities. In Minnesota, the Master Gardener program is coordinated by University of Minnesota Extension and has strong ties to the research and outreach of the Department of Horticultural Science.” (<http://www1.extension.umn.edu/master-gardener/about/>)



Master Gardener Volunteer Leaders

In Minnesota, each of the three biochar sites has team leaders and approximately 10 other volunteers supporting the needs of each site. All of the Master Gardener volunteers completed a specialized training to learn about biochar and the CenUSA grant.

Master Gardeners were involved in many facets of the project including building fences, planting and maintaining the gardens, collecting and recording data measurements and harvesting crops. A large percentage of the edible crops were donated to local food shelves providing hundreds of pounds of produce for families in need. Volunteers on this project also participated at State or County fairs, horticulture field days and other community events to teach the public about biochar and their research on this project.

CHALLENGES IN THE GARDENS

The plants selected at each site were designed to include basic plants that typical homeowners would grow such as annuals, perennials, vegetables and herbs. The design was laid out with short annual plants in the front and perennials near the back. The edible crops that were grown included: green beans, tomatoes, green bell and hot peppers, Swiss chard, leafy kale, cucumbers, lettuce, asparagus, potatoes, and basil. The ornamental crops included zinnias, petunias, marigolds, chrysanthemums and shrub roses. Seeds were started by a local commercial greenhouse. The perennial crops – roses, mums, and asparagus – were purchased from a local commercial grower.



Andover site

Germination

After the gardens were planted, there were some germination issues with the beans in two sites. Teams from those sites opted to replant, but by the time the second planting germinated, the Swiss chard was so large it overshadowed the bean row too much. The results were so poor that measurements of data were not taken. The potatoes also did not perform well. Project leaders believed this was due to the potato sets being shipped too early in the season requiring longer storage. This resulted in some mold issues on the tubers. The tubers were kept under refrigeration; however, rooting and emergence was sporadic and poor overall.

Watering

In order to replicate a typical home garden, overhead irrigation was used at all three sites on all plots. The SPC site was on a regulated irrigation system. Volunteers discovered the CTRL plot received overspray from a neighboring research plot. The ARB site was watered manually by volunteers with a hose and sprinkler. The AND site was watered by a hose and sprinkler that was on a timer.

Weeds, Pests and Diseases

Other challenges in the gardens included a plethora of weeds from Canada thistle to poison ivy. Japanese Beetles were prolific in the SPC and ARB sites. Aster yellows disease destroyed most of the marigolds and petunias in all three sites. Air temperatures were high most of the summer and moisture was plentiful early in the season, but soon ended in drought. The photograph below shows a marigold infected with aster yellows disease embraced by purslane next to a healthy marigold.



Aster yellows on marigold & weeds

Before planting, the AND site was covered with small trees and underbrush including poison ivy. The poison ivy roots continued to re-sprout throughout the season. The Extension Master Gardeners kept it under control by using herbicides around the exterior perimeter of the garden and hand pulling any sprouts that came up in the garden. Some of the volunteers were nervous about eating produce that may have come in contact with poison ivy. Upon researching this concern with staff at the Minnesota Department of Health, they felt the risk was low, but if the poison ivy roots came into contact with root vegetables like potatoes, it was recommended that volunteers peel them prior to eating them.

Overcrowding & Nutrient deficiency

The nitrogen-amended soils at the SPC site and the ARB sites resulted in overcrowding of some of the rows. To allow the kale to grow to mature size, the Swiss chard was harvested earlier than originally planned.

Overall, the gardens at the SPC and the ARB had the most vigor due to loamy clay soil's nutrient and water holding capacity. However, the AND site with coarse, sandy soil showed early signs of nutrient deficiency: smaller plants, yellow-green leaves and lower yields. In addition, heavy rains and regular watering had diminished the effectiveness and availability of the slow-release fertilizer applied at planting relatively quickly. At all sites, fertilizer was applied only at planting time.

DATA COLLECTION*

Extension Master Gardener volunteers collected a variety of data over the season. Some of the data collected included weights and counts on crops such as potatoes, cucumbers and tomatoes, plus plant heights, plant widths, and bloom production. Results from that collection process follows.



Volunteers collecting data at ARB site

RESULTS

Asparagus

Jersey Knight Hybrid asparagus 2-yr roots were selected as the only perennial vegetable in the gardens. This variety was chosen because of its adaptability to a variety of soils and its resistant to rust, Fusarium wilt and other diseases. Five roots were planted in each treatment. There was no harvest in the first year, but stalk growth was measured.

Asparagus - Results based on average height in inches			
	CTRL	TRT1	TRT2
AND	NA	NA	NA
ARB	32.13	32.00	27.38
SPC	23.00	23.85	26.53
Grand Total	27.87	28.20	26.98

Variances: The 2-year roots arrived too early for planting and were stored in refrigeration. By the planting date, some of the roots appeared somewhat moldy; however, they showed no sign of rot, and so were planted. The asparagus appeared to have fairly steady growth.

Biochar Results on Asparagus: The ARB site appeared to show a slight decline in growth in the TRT 2 plot compared to the CTRL and TRT 1 plots. The SPC site showed a slight growth improvement in the TRT 2 plot. The Andover results were not available.

**Approximately 30 volunteers were involved in measuring data and recording the results. There are notably some levels of error based on interpretation and subjective opinions. For that reason, there will be no results-posted regarding taste, stem strength or plant coloration.*

Basil

Italian Large Leaf basil was the variety selected for its popularity, mild sweet flavor, high yield and slow bolting. Date to maturity is 40-65 days. Seeds were started indoors in mid-April.

Variances: Plants were deadheaded to extend the season. Plants became woody, exhibited yellowing of the leaves and started defoliating early. The volunteers determined the basil plants were exhibiting symptoms similar to those of basil downy mildew, a new pathogen reportedly found in Minnesota in 2012. The basil was harvested in early August. The results for plant height and weight are below.

Basil - Results based on sum of weight in pounds & ounces			
	CTRL	TRT1	TRT2
AND	11.17	5.06	9.25
ARB	7.30	7.19	5.83
SPC	22.50	22.38	22.31
Grand Total	40.97	34.63	37.39
Basil - Results based on average height in inches			
AND	23.03	17.72	18.94
ARB	18.59	19.80	19.84
SPC	20.03	20.71	20.88
Grand Total	20.27	19.65	20.03

Biochar Results on Basil: In the AND site, the CTRL outperformed the other 2 treatments. TRT 2 weight is almost 2X TRT1. Volunteers believed this could be due to morning shade in this area of the plot and thus less droughty conditions. The ARB site had bolted and defoliated prior to weighing. There did not appear to be any significant growth variances at the ARB and SPC sites between treatments.

Beans

Blue Lake Bush beans were selected for this project based on its growth habit and popularity among gardeners. They typically grow a sturdy bush 15-18" tall. When mature, the pods are 6-7" and free of strings and fiber. Days to maturity are 52 days. Seeds were direct sown according to label directions on May 21-23 and the projected date of harvest was July 14-16.

Variances: There were multiple germination issues at both the SPC and AND sites. The ARB site had better germination possibly due to a more accurate planting depth, and based on their success, they harvested their first beans the week of June 23 approximately 3 weeks before the estimated date of maturity.

Beans were replanted at both the SPC and AND sites, but by the time they germinated, the rows became shaded by other nearby crops. Due to the lack of germination, the bean crop is considered a failure in 2012.

Cucumbers

The variety selected was Tasty Green Hybrid Cucumber. These were selected based on the description of being disease resistant, 9-10" in length and a good variety for trellises. The maturity date listed was 62 days. Seeds were started April 28th and were transplanted May 21-23 with the projected harvest date to be July 22-24 based on the transplant date and date-to-maturity.



First cucumber harvest at AND site

Variances: There were nine cucumbers planted at each site; three for each treatment. Each site lost one plant. In AND, one plant was lost in TRT 1; ARB lost one in the CTRL, and SPC lost one in TRT 2. Both the ARB and AND sites were the first to harvest cucumbers during the week of June 30th, approximately three weeks ahead of schedule. By the first week of July, all three sites reported harvests. The following tables show the final results of counts and weights measured up until the first frost.

Cucumber - results based on average height in inches			
	CTRL	TRT 1	TRT 2
AND	33.75	28.63	32.95
ARB	101.27	139.49	124.54
SPC	82.49	91.69	100.89
Grand Total	217.51	259.82	258.38
Cucumber - results based on count			
AND	40	27	33
ARB	92	115	109
SPC	100	119	120
Grand Total	232	261	262

Biochar Results on Cucumber: By calculating the variances in the missing plants, it appears that in the AND site, that TRT 1 performed better by weight compared to the CTRL, but about the same based on count. TRT 2 performed worse than CTRL and TRT 1 in both weight and count. At the ARB site, the CTRL performed better by weight and count. At the SPC site, TRT 2 outperformed the CTRL & TRT 1 plots.

Kale

Blue Curled Vates kale was selected for its durability in the garden. It was important to maintain some aesthetics in the garden past the first frost and this crop provided for that. Seeds were started indoors on April 21st. The date to maturity was 60 days and the recommended harvest dates would have been June 21-2. However, kale performs well even past the first frost. Master Gardener volunteers instead deadheaded decayed lower leaves. A harvest date was selected for all sites to take place between the dates of September 15-22.



Kale harvest at SPC

Kale - results based on sum of weight in pounds & ounces			
	CTRL	TRT 1	TRT 2
AND	7.56	10.61	15.88
ARB	25.90	34.30	25.29
SPC	29.39	37.85	44.33
Grand Total	62.85	82.76	85.49
Kale - results based on average height in inches			
AND	11.00	13.29	17.64
ARB	18.17	18.97	16.97
SPC	17.49	16.04	17.45
Grand Total	15.92	16.32	17.33
Kale - results based on average width in inches			
AND	20.71	21.71	25.71
ARB	28.17	27.48	23.97
SPC	26.80	24.52	26.04
Grand Total	25.59	24.80	25.20

Initially, the kale and Swiss chard were inter-planted for aesthetic reasons, but that resulted in overcrowding. It was decided to harvest the Swiss chard to give room for the kale for the duration of the season. There were six plants in each treatment.

Variances: Overall, the crops exhibited good health, especially in the nitrogen-amended sites at SPC and ARB. The SPC site did lose one plant in their CTRL plot due to bacterial rot.

***Biochar Results on Kale:** the nutrient deficient AND site compared to the Nitrogen rich SPC and ARB sites really shows

substantial differences in growth overall.

The AND site does show signs of nutrient/moisture holding capacity from the biochar in Trt 1 and Trt 2 (Trt 2 also has morning shade).

Considering the loss of one plant in the Ctrl plot at SPC, the Ctrl plot seemed to perform better in terms of weight. At the Arb site, Trt 1 performed slightly better, while Trt 2 showed decline.

Lettuce

Red Sails Loose Leaf lettuce was selected based on its resistance to early bolting, tip burn and bitterness. This variety was a favorite AAS winner for salads forming large clumps approximately 10" across. The maturity date was listed as 40-45 days-seeds were started indoors. Based on that date of maturity the harvest date would have been July 1-3. Since that was a national holiday week and knowing many of our volunteers would not be available we opted to harvest during the week of July 14th.



After the washout - AND Site

Variances: A major rainstorm in late May 2012 washed out some of the transplants in the AND site two days after planting, resulting in 20-30% transplant loss. Each treatment, CTRL, TRT 1 and TRT 2 were planted with 15 plants each. After the storm there were 10 (30% loss), 12 (20% loss) and 12 (20% loss) respectively at the AND site. Hot temperatures right after transplanting was another problem. The ARB site experienced decline from heat and harvested eight, 13 and 12 plants. The SPC sites suffered the most due to a Japanese beetle (JB) infestation with only five, seven and three plants harvested. The ARB site experienced some JB damage, but not as severely. The AND site did not have JB pest issues. The results of the weights reflect the decline at the time of harvest. On the upside, the nitrogen-amended soils at the SPC and ARB initially produced larger lettuce heads than those at the AND site.

Lettuce - results based on average height in inches			
	CTRL	TRT 1	TRT 2
AND	7.83	8.15	11.45
ARB	9.25	9.38	10.00
SPC	8.31	7.94	10.09
Grand Total	8.46	8.49	10.51
Lettuce - results based on average width in inches			
	CTRL	TRT 1	TRT 2
AND	10.93	9.00	14.50
ARB	14.38	17.50	18.63
SPC	12.98	12.88	12.03
Grand Total	12.76	13.13	15.33
Lettuce - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	3.11	2.12	9.96
ARB	5.19	6.44	6.19
SPC	3.06	1.29	2.05
Grand Total	11.36	9.85	18.19



Japanese beetle damage at SPC

Peppers

Two pepper plants were selected. The Mariachi Hybrid pepper and King Arthur Hybrid Sweet Bell pepper. Mariachi, a 2006 AAS winner, is considered a high-yielding plant variety that grows fruits 3-4" long when mature. It is an upright bush, 18-24" in height and matures in 62 days. Seeds were started indoors on April 7th. The King Arthur peppers are large 4 ½" bells that grow on 22' plants. They, too, are known for high yields and are tolerant to Tobacco Mosaic Virus (TMV) and Potato Virus Y (PVY).

Variances: The peppers were inter-planted for aesthetic reasons. Unfortunately, on planting day, the varieties became mixed, thus unequal numbers of peppers were planted in each treatment at each site. Due to this error, the data comparison is inconclusive and not presented in this report.

Potatoes

'**Kennebec**' potato sets were selected based on their history of excellent yields, disease resistance and having large tubers. They are considered a midseason variety maturing in 80-100 days. The plants grow to 2-3' tall and 18-24" wide.



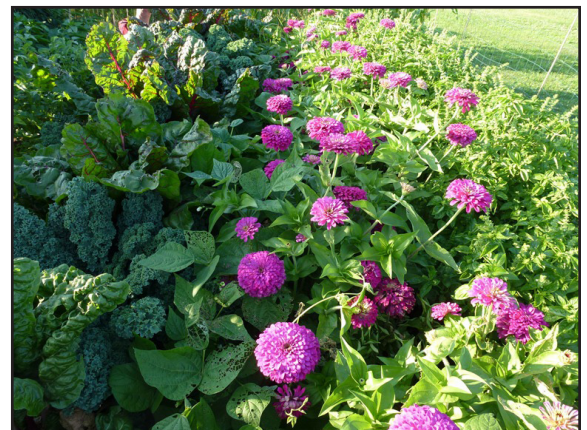
AND site - photo by Dave Hansen

Potatoes - results based on sum of weight in pounds & ounces			
	CTRL	TRT 1	TRT 2
AND	NA	NA	NA
ARB	3.47	1.69	5.58
SPC	1.01	4.01	2.02
Grand Total	4.48	5.70	7.60
Potatoes - results based on average height in inches			
AND	NA	NA	NA
ARB	22.22	22.22	23.67
SPC	19.07	19.63	18.81
Grand Total	20.84	21.09	21.54
Potatoes - results based on average width in inches			
AND	NA	NA	NA
ARB	28.00	28.44	27.78
SPC	24.29	25.44	21.57
Grand Total	26.38	27.13	25.06

Variances: There was poor root and stem emergence across all three locations. Each treatment, CTRL, TRT 1 and TRT 2 were planted with five sets each. The ARB site produced three, one and five plants respectively. The SPC site produced two, four and two plants. There was no data available from the AND site. All weight results were very poor. The data on this crop is inconclusive.

Swiss Chard

Bright Lights Swiss Chard, a 1998 AAS winner, was selected for its popularity for home gardens and its colorful petioles. The plants grow to a height of 20" and are mature after 60 days. Seeds were started indoors April 21st resulting in the projected harvest date of June 21-23. The Swiss chard was inter-planted with the kale. Harvest was scheduled for later in the season to extend the aesthetic appeal of the garden, but due to a very large plants causing overcrowding, the chard was harvested during the week of August 11th.



Overcrowding - SPC site

Swiss chard - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	2.56	4.06	7.19
ARB	4.94	29.69	22.56
SPC	27.81	16.00	21.94
Grand Total	35.31	49.75	51.69
Swiss chard - results based on average height in inches			
AND	15.00	15.57	19.57
ARB	22.00	24.19	21.81
SPC	21.31	19.01	19.39
Grand Total	19.44	19.59	20.26
Swiss chard - results based on average width in inches			
AND	19.43	20.71	24.14
ARB	35.36	33.76	33.13
SPC	22.51	17.58	21.18
Grand Total	25.77	24.02	26.15

Variances: Originally, there were six plants in each treatment. The ARB site reported loss of two plants in each of CTRL and TRT 2. The other sites did not indicate the number of plants at harvest so any loss is unknown. No explanation was recorded regarding the low weight for the CTRL crop at the ARB site compared to the other treatments. The AND site recorded an abundance of leaf spot at all three treatments.

Biochar Results on Swiss Chard: Between the crop loss and leaf spot diseases causing decline in the plants, the weight results are inconclusive.

Based on the average growth, there appeared to be minor decline between the Ctrl and Trts 1 & 2 on the healthy soils and minor improvement in both treatments compared to the Ctrl at the AND site.

Tomatoes

The **'Celebrity'** hybrid tomato, a 1984 AAS winner, was selected for its outstanding disease resistance. These tomatoes are determinate plants that are generally supported well by short stakes or cages. According to the growers, the fruits are large, about 8-10 oz. and are very productive with the ability to produce under a broad range of conditions. They reach maturity in 72 days and grow to a height of 3-4' and width of 3'. Seeds were started indoors on April 7th and the projected date of harvest was mid-July. Five plants were grown in each treatment.

Variances: The TRT 2 plot at the AND site with the morning shade added a significant improvement in tomato yields. The nitrogen-amended soils in both the SPC and ARB sites produced very vigorous plants. At the SPC, the cages collapsed in a strong wind from the weight of the tomatoes plants and needed additional staking.

Biochar Results on Tomatoes: Overall, the CTRL plots outperformed the TRTs 1 & 2 plots in both count and weight of tomato yields in all three sites with the exception of TRT 2 in AND (see variance). Considering the morning shade and increased moisture in TRT 2 at the AND site could account for the better results in that plot.

Tomato - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	39.53	37.11	81.40
ARB	141.23	139.98	124.37
SPC	202.11	186.46	171.73
Grand Total	382.87	363.55	377.50
Tomato - results based on sum of count			
AND	125	104	154
ARB	365	302	264
SPC	591	549	511
Grand Total	1081	955	929
Tomato - results based on average height in inches			
AND	33.88	36.13	36.13
ARB	38.14	38.86	36.86
SPC	40.24	38.84	38.02
Grand Total	37.51	37.94	37.05
Tomato - results based on average width in inches			
AND	31.63	31.63	33.50
ARB	34.86	34.86	31.43
SPC	41.51	38.69	36.53
Grand Total	36.28	35.22	34.03

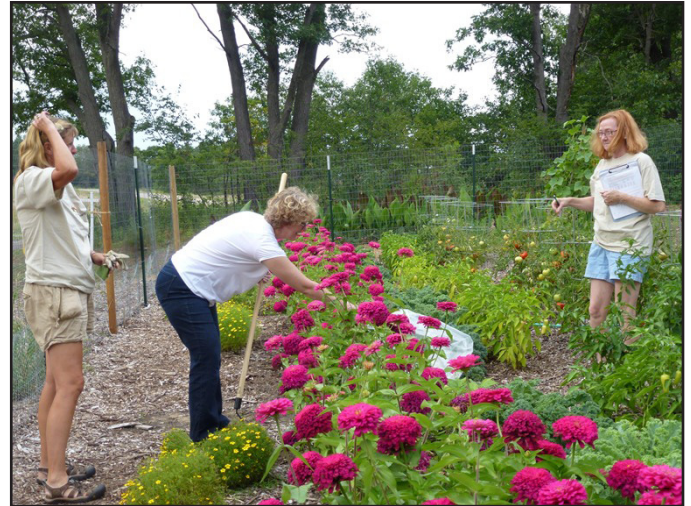
The AND site showed a decrease in count of tomatoes of 16.8% in TRT 1 compared to the CTRL plot. The Arb site showed a decrease of 17.3% in TRT 1 and a larger decrease of 27.8 % in TRT 2 compared to the CTRL plot. The SPC site showed a decrease of 7.1% in TRT 1 and a larger decrease of 13.5% in TRT 2 compared to the CTRL plot.

ANNUALS

Marigolds

The marigolds that were selected were '**Mexican Marigold-Tagetes**', Golden Gem Seeds, **Signata pumila**. They were the shortest crop and were chosen for their bloom longevity and short size with a maximum height of seven inches.

The SPC site showed the first bud break the week of June 23 in the CTRL and TRT 2 plots. By the next week the ARB site had bud break in all three treatments with TRT 1 showing a little stronger show. The AND site suffered early washout from a heavy rainstorm and struggled after that. Within the next few short weeks, the marigolds became very poor performers. At the ARB site there had been some early drought effects, plus damage from wildlife, possibly birds. Aster yellows disease became a problem in all three sites and plants were removed when symptoms appeared. Because of these issues, it was difficult to get viable data.



Zinnias at AND site

Petunias

The petunias that were selected were the specialty 'Pinstripe' variety. Performance data on growth habit and disease resistance was not available. Plants were started by plugs early in the season. By the planting date they were in full bloom. The petunias performed poorly much like the marigolds. They also succumbed to aster yellows disease and many plants were removed. Because of these issues, it was difficult to get viable data.

Zinnias

The zinnias became the star performers among the annuals in the gardens. The variety selected was 'Uproar Rose Hybrid'. They were selected for their bold deep magenta color and large blooms that measure 4-6 inches across, and for their disease resistance and non-stop performance. Seeds were started indoors. With aster yellows disease prevalent in the marigold and petunia crops, the zinnias seemed to tolerate it better with only a couple of flowers showing symptoms. There were no significant effects between treatments on blooming times. Each treatment bloomed at the same rate per location. The SPC location bloomed a little faster than the other two sites.

Zinnia - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	24.77	26.18	26.92
ARB	26.50	25.40	24.17
SPC	22.38	23.33	23.13
Grand Total	24.55	24.97	24.74
Zinnia - results based on average width in inches			
AND	20.90	21.70	24.26
ARB	23.11	20.89	20.56
SPC	22.33	21.68	21.69
Grand Total	22.11	21.41	22.19

Biochar Results on Zinnias: There was a slight increase in average height and width in the TRT 1 plot over the CTRL plot in the AND site.

There was a slight decrease in average height and width in the TRT 1 & 2 plots compared to the CTRL plots in both the ARB and SPC sites. There did not appear to be a significant difference between TRTs 1 and 2 at either site.

PERENNIALS

Chrysanthemums

There were three mums selected for the gardens. All were 'Mums of Minnesota' varieties developed by the University of Minnesota. All are cold tolerant and considered prolific and disease resistant.

- The first variety, 'Betty Lou,' was selected for being an early bloomer- starting in August. The plant grows to 10-12" in the first year and 2.5-3' when it reaches maturity. The average plant width is 30". Blooms measure about 2.5".
- The 'Gold Country' variety was selected because it is a late-season variety blooming in mid-September. Mature height reaches 21" and width is also 21". Blooms are a peachy bronze tinged with yellow and are 4.5" in width.
- The third variety of mums selected was 'Maroon Pride.' This plant matures to a height of 15-18" with a width of up to 30". The dark red flowers are 4.5" and this one blooms in early September.

Biochar Results on Chrysanthemums: Results are very inconsistent with some sites and plots showing increases of growth, while others showing decreases. Results are inconclusive from this first year. Hopefully, years 2-4 will show more consistency in the results.



Mum "Betty Lou" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	6.86	16.11	11.54
ARB	10.33	7.00	7.00
SPC	8.93	14.28	13.52
Grand Total	8.16	14.64	12.20

Mum "Betty Lou" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	8.36	15.86	13.46
ARB	12.67	8.00	9.00
SPC	12.37	22.22	18.60
Grand Total	10.64	18.43	15.66

Mum "Gold Country" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	13.21	15.07	10.00
ARB	9.67	7.00	9.67
SPC	10.87	12.85	13.10
Grand Total	11.78	13.48	11.42

Mum "Gold Country" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	12.14	11.43	9.86
ARB	8.33	6.00	7.67
SPC	12.92	14.90	13.80
Grand Total	12.15	12.76	11.50

Mum "Maroon Pride" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	12.57	13.79	11.25
ARB	6.50	8.00	10.00
SPC	13.97	14.45	13.30
Grand Total	12.85	13.73	12.16

Mum "Maroon Pride" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	16.07	20.14	14.00
ARB	8.50	8.50	10.00
SPC	24.03	26.45	22.13
Grand Total	19.44	22.44	17.68

Northern Accent Shrub Roses

The roses selected were 'Northern Accent' shrub roses developed by the University of Minnesota. These are of the polyantha variety and die back to the crown in the winter. By early summer, these plants grow to 2' tall, and are very prolific bloomers. These cold hardy roses need no special care and no pruning is required except for removal of deadwood.

- The 'Lena' variety has a single-flowered blush pink blossom reminiscent of apple blossoms. It grows to 2.5' tall and 2-3" wide.
- The 'Ole' variety is a semi-double blush pink rose that fades to white. It grows to a height of 2.5-3'.
- The 'Sven' variety grows between 2.5- 3' height and their small 1-2" flowers are mauve in color and fragrant.

Biochar Results on Northern Accent Shrub

Roses: Most of the roses seemed to perform slightly better in growth in the CTRL plot at the AND site. Most of the roses in the ARB and SPC sites showed some slight improvement in the TRT 1 & 2 plots over the CTRL plots. There appeared to be a lot of inconsistencies in the data to determine if biochar had any improvement over bloom performance.

Roses 'Lena' - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	22.75	17.17	16.00
ARB	17.67	18.33	18.67
SPC	19.41	19.63	20.11
Grand Total	20.05	18.82	18.85
Roses 'Lena' - results based on average width in inches			
	CTRL	TRT1	TRT2
AND	24.33	22.00	23.17
ARB	21.67	22.00	21.33
SPC	23.82	26.57	26.16
Grand Total	23.67	24.78	24.75

Roses 'Ole' - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	16.50	13.83	14.17
ARB	19.00	15.00	19.00
SPC	18.79	21.04	18.63
Grand Total	18.18	18.52	17.44
Roses 'Ole' - results based on average width in inches			
	CTRL	TRT1	TRT2
AND	23.83	20.67	23.17
ARB	18.00	14.50	14.50
SPC	25.77	28.16	29.43
Grand Total	24.53	24.88	26.36

Roses 'Sven' - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	14.67	16.83	14.83
ARB	17.67	17.67	17.33
SPC	17.96	19.63	18.75
Grand Total	17.07	18.64	17.54
Roses 'Sven' - results based on average width in inches			
	CTRL	TRT1	TRT2
AND	24.17	21.00	20.50
ARB	19.67	18.00	20.00
SPC	24.73	23.14	25.80
Grand Total	23.92	21.91	23.66

SUMMARY

The more we learn about biochar, the more we need to learn. From an overall standpoint, there appeared to be some benefit of using biochar in the nutrient-depleted sandy soils at the Andover site for some crops. Yet, there was a decrease in growth in some plants and higher yield in others. In the Arboretum and St. Paul campus sites, we noted similar results, but more crops seemed to decline with biochar than without it.

Extension Master Gardener volunteers have been instrumental and valued in their support on this research project. During this first year, volunteers learned about the importance of accuracy, and project leaders learned about instructing volunteers in data collection. Our goal in 2013 will be to continue to improve and streamline data collection, making sure we are asking volunteers to collect the data most important to research results. One of the biggest changes will be the timing of data readings. All crops will have measurements taken or harvested only one time during the season based on the maturity dates, and no longer will volunteers take weekly readings. Projects leaders are also focused on developing a clearer and easier method for documenting the data to help guarantee more consistency in data reporting.

As we move into the next phase of our research, it will be valuable to compare across the four years slated for this project.



Volunteers at AND site



"Our vision is to create a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the proposed system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon sequestration."

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