2019 GLBRC Standard Sampling Report

Biofuel Cropping System Experiment (BCSE)

Soil

Soil was sampled just once in the BCSE plots in 2019. Samples were taken December 3 in all blocks or replicates (R) 1-5 of all treatments (G) 1-10. Soil was sampled using ¾" diameter push corers. Three cores (0-25cm) were taken from each of the three sampling stations and all 9 cores composited for each plot. On December 2, soil was sampled from the subplots. Nine cores (0-25cm) were composited from each subplot. Soil was also sampled from rainout sheltered areas of G5R2-5 (see Rainfall Manipulation Experiment) on December 2. Four cores (0-25cm) were taken from each area.

Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium will be completed by Cathy McMinn during winter 2019-2020. All samples will be air-dried and archived. Subsamples from the annual treatments only (G1-3) will be sent to the MSU Soil and Plant Nutrient Lab for standard analysis which includes pH, lime requirement, P, K, Ca, and Mg in 2020.

Gas

Gas was not sampled on the BCSE as part of the core sampling efforts in 2019. However, Debasish Saha (Robertson lab post-doc) sampled greenhouse gases from static chambers in G1 and G5 using the Mobile Integrated Cavity Offset Spectroscopy (MICOS) system. Jenie Gil Lugo (Nathaniel Ostrom lab post-doc) and Sam Decamp (Ostrom lab staff) also sampled static chambers in G5 during the 2019 field season.

The automated gas sampling and analysis system in block 1 was dormant in 2019.

Water

From April 1 through October 28, 2019, 223 water leachate samples were collected at the BCSE and Switchgrass Nitrogen Rate Experiment lysimeter sites from soil water samplers buried in the plots. These samples were analyzed for anions, cations, and NH4-N via ion chromatography. Sampling and analysis was completed by Dave Weed, Hamilton lab.

Plants

Plant biomass samples were taken from the BCSE plots at their peak to measure above-ground net primary production (ANPP). No species separations were completed on samples taken in 2019. Plots were sampled as follows: G9 on August 9; G5, 7, 10 on August 20-26; G8 on September 18; G3 on September 24-25; G1 on September 27-30; G2 on September 30-October 1 and G6 on October 9-10. Species composition and height were measured with three transects per plot following the line-point intercept protocol. Transects were completed around the same time that each treatment was sampled for ANPP, except for G1 where no transect data was collected. On December 17, the residue remaining following machine corn stover collection was sampled from the ground in G1 to evaluate collection efficiency. Poplar trees were planted into G8 on June 27, 2019. Two ground traps were deployed in each plot on September 18 to collect leaf litter as leaves fell from the trees. Litter from the traps was collected every two weeks until the trees were bare and traps were pulled from the field on December 10. Since the trees were small, ground traps may not

have accurately estimated the litter fall. Poplar leaf litter was collected from the ground within two representative areas in each plot on December 6 to compare to the litter trap biomass. G8 poplar tree damage from caterpillars, deer and other was assessed on October 10 and 11. On November 20, to track poplar growth, ten trees were randomly chosen from each G8 plot and the main stem diameter measured at 15cm above the ground. All plant material from all sampling was dried at 60°C for at least 48 hours. The dried biomass will be weighed, ground and archived. Combustion analysis for carbon and nitrogen determination will be completed by Stacey VanderWulp.

Phenological development was tracked using phenocams positioned on each plot in block 1. In addition, Cheyenne Lei, graduate student with Jiquan Chen, has albedo towers installed in G1, 2, 5, 6, 7, 9 and 10 of block 1. Instruments on these towers measured radiation, temperature, precipitation and recorded images of vegetative growth. Personnel from the Chen lab also measured leaf chlorophyll concentrations periodically using a SPAD meter.

Fourteen drone flights were completed over the BCSE from March 27-November 26, 2019. Flights collected albedo data and visual/multispectral imagery. All flying was done by Kevin Kahmark.

Yield data was collected from all plots and subplots during mechanical harvest. A sub-sample from the machine harvest of these plots was saved. This biomass is dried and will be ground, archived, and analyzed for carbon and nitrogen.

BCSE Subplots and Microplot

Stover non-removal subplot (G1 R1-5): This is a 15 foot wide strip along the west edge of each G1 plot where corn stover is not collected. The corn stover in the rest of the plot is collected after harvest. Besides the soil samples collected in December (see BCSE soil), there was no other sampling done here. Yield data was collected at harvest here.

Unfertilized subplot (G2, 5-7, 9 R1-5): This is a 15 foot wide strip along either the east or west edge of each G2, G5, G6, G7 and G9 plot where no nitrogen fertilizer is applied while the rest of the plot received fertilizer. Besides the soil samples collected in December (see BCSE soil), there was no other sampling done here. Yield data was collected at harvest here.

Fertilized subplot (G10 R1-5): This is a 15 foot wide strip along either the east or west edge of each G10 plot where nitrogen fertilizer is applied while the remainder of the plot receives none. Besides the soil samples collected in December (see BCSE soil), there was no other sampling done here. Yield data was collected at harvest here.

Rainfall Manipulation Experiment (G5 R2-5): Beginning in 2018, rainout shelters were installed in G5R2-5. The shelters are 12' long x 12' wide and exclude about 60% of rainfall. The area under the rainout shelter and a comparable unsheltered area nearby were harvested by hand just prior to machine harvest in these plots. Soil samples were collected from the sheltered area in December (see BCSE soil).

Scale-up Experiment

Soil

Soil was sampled on December 4 in all the GLBRC scale-up fields at Lux Arbor and Marshall Farms. Soil was sampled using ¾" diameter push corers. Ten cores were taken to a depth of 25 cm at each of the 10 stations in each plot. Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium will be completed by Cathy McMinn during winter 2019-2020.

These soil samples will be air-dried and archived. Subsamples from the annual treatments only (L1, M1) will be sent to the MSU Soil and Plant Nutrient Lab for standard analysis which includes pH, lime requirement, P, K, Ca, and Mg in 2020.

Gas

Gas was not sampled in the Scale-up plots in 2019. Each of the seven fields has a CO_2 flux tower that measures the flux of CO_2 into and out of the canopy/soil and allows for development of a complete carbon budget based on rates of carbon sequestration and loss from these different systems.

Plants

Plant biomass samples for ANPP were not taken from any scale-up plots in 2019. Transects through the switchgrass, prairie and reference fields were used following the same line-point intercept protocol as on the BCSE to collect data on species composition and height. This data was collected between September 9 and 13. The scale-up prairie fields were not fertilized in 2019, so no microplot plant samples were taken.

The Basso lab had the responsibility of flying drones over the scale-up sites. They used a DJI M100 to fly over the fields from May to October 2019. Approximately every 2 weeks, the corn, switchgrass and native prairie fields were flown (L1-3, M1-3). The UAV flew at 122m (400ft) and was equipped with a visual camera and a Micasense RedEdge 3. Over the course of the season at least ten RGB, NDVI and NDRE images per field were collected.

Yield data was collected from all harvested sites (L1-3, M1-3) when mechanically harvested.

Marginal Land Experiment (MLE)

Soil

Soil samples were taken from all MLE sites in the fall of 2019. They were sampled in this order between October 8 and November 6: WN (Rhinelander), MN (Escanaba), WC (Hancock), MC (Lake City) and MS (Lux Arbor). Each half of the split plots (fertilized and unfertilized) was sampled separately with six 0-25cm cores/split plot composited. Beginning in 2018, as on the BCSE, rainout shelters were installed in each G5 plot at all the MLE sites. The shelters are 12' long x 12' wide, exclude about 60% of rainfall and are installed on the fertilized split plot. Soil was sampled in the sheltered areas on the same day as the split plots. Six cores (0-25cm) were taken from each sheltered area. Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium will be completed by Cathy McMinn during winter 2019-2020. All samples will be air-dried and archived. A subsample from each could be sent to the MSU Soil and Plant Nutrient Lab for standard analysis. This has been done in the past but is not planned for 2019 soil.

Plants

Plant biomass samples were taken from all MLE sites for ANPP in late August and September. Samples were not sorted to species. Species composition and height data was collected in all plots, at all sites in late August and early September using a line-point intercept protocol. Species were identified and height measured along two transects in both the fertilized and unfertilized split plots.

Yield data was collected from all of the mechanically harvested plots (G5-7, 9, 10) separately in the fertilized and unfertilized split plots. G11 was not harvested, so hand samples were taken there to look at production. Additionally, the area under the rainout shelter and a comparable unsheltered area nearby were harvested by hand. Subsamples of all harvested materials (with the exception of the G5 unsheltered comparison area) were saved and will be ground, cataloged and stored on MSU main campus. The majority of this work was done by personnel from Kurt Thelen's lab, led by Todd Martin. Species composition transects were completed by a five person crew from the Robertson lab.

Poplar trees were planted in all G8 plots in May and June this year.

At least one drone flight was completed at each of the MLE sites during 2019. Flights collected albedo data and visual/multispectral imagery. All flying was done by Kevin Kahmark.

Weather

A weather station is installed at each MLE site. Each weather station collects air temperature, precipitation, solar radiation, relative humidity, soil moisture and temperature at 10 and 25cm depths, and wind speed.

Switchgrass Nitrogen Rate Experiment (formerly Nitrogen/Harvest)

Soil

Soil samples were collected on December 9, 2019. Soil is sampled in the fall of odd-numbered years only. Samples will be air-dried and sent to the MSU Soil and Plant Nutrient Lab for standard analysis which includes pH, lime requirement, P, K, Ca, and Mg.

Water

Soil water samplers were used to collect water from the soil in blocks 2-4. Collections were made in April-October 2019. Like the BCSE water samples, these were analyzed for anions, cations, and NH4-N via ion chromatography. In addition, these were also processed and analyzed for non-purgeable organic carbon (NPOC) and total dissolved nitrogen (TDN), and will be analyzed for total dissolved phosphorus (TDP). All sampling and analysis was completed by Dave Weed.

In the summer of 2019, a URA project titled, "Biogenic silicon in switchgrass - changes over nitrogen gradient and over time" was undertaken and completed. The project involved extracting silicate from archived switchgrass gradient biomass samples (2011 and 2018). Fifty four samples and replicates were extracted and analyzed for silicate content. It was determined that time was not a significant factor in silicate uptake, but that nitrate fertilization rates did have an effect. The undergrad researcher working on this project developed a poster and brief talk regarding the experimental results. Further research on this topic is tentatively planned for the summer of 2020.

Plants

Yield data was collected from all plots during mechanical harvest. A sub-sample from the machine harvest of these plots was saved. This biomass is dried and will be ground, archived, and analyzed for carbon and nitrogen.

Switchgrass Variety Experiment

Soil samples were collected on December 13 from all split plots (fertilized and unfertilized) to 25cm depth. The soil was sieved, air dried and a subsample will be sent to the MSU Soil and Plant Nutrient Lab for standard analysis which includes pH, lime requirement, P, K, Ca, and Mg.

Project 1: Determination of differences in associative nitrogen fixation rates between two high-yielding switchgrass varieties, Cave-in-Rock and Kanlow

Two plants of each variety from plots in block 1-3 were dug up, potted and transported to the greenhouse. Isotopic methods ($^{15}N_2$ tracer gas) were used to determine the amount of associative nitrogen fixation of these plants. In addition, a laboratory experiment was conducted with biomass from the same crops and plots (above and belowground) and rhizosphere soil (0-30cm) to test associative nitrogen fixation. This project was done as independent study by Nyduta Mbogo (summer REU 2019).

Project 2: Study of phenological and chemical composition differences among all switchgrass varieties

From May 26 through October 4, aboveground switchgrass biomass was collected from the unfertilized portion of all twelve varieties, approximately every two weeks or more, for a total of seven harvests. These samples were sorted according to phenological stage, oven dried and processed for submission to the GLBRC Core Facilities lab for a complete analysis of the carbon compounds and fermentation index. They will also be analyzed for carbon and nitrogen in the Robertson Lab. Additionally, LAI measurements were taken and root biomass collected. LAI measurements were taken from the same plots manually (same week as biomass harvest) with a ceptometer. The Basso lab flew a drone over the experiment about every two weeks starting at peak until harvest collecting RGB, NDVI and NDRE imagery. Root biomass samples were collected with a Geoprobe from the unfertilized portion of each plot and select varieties from the fertilized portion right after harvest (late October, early November). The total number of root deep cores taken was 72, 54 from unfertilized and 18 fertilized. Each core will be split into 4 depths (0-10, 10-25, 25-50, and 50-100 cm) and roots will be washed using an elutriator on MSU main campus.

Written by Stacey VanderWulp (with contributions from Carolina Cordova, Kevin Kahmark, Cheyenne Lei, Ruben Ulbrich and Dave Weed)

Archived Material

Experiment	sample type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GLBRC BCSE	plants	X	X	X	X	X	X	X	X	X	X	X	X
GLBRC BCSE	surface soil	X	X	X	X	X	X	X	X	X	X	X	X
GLBRC BCSE	deep core soil	X					X				X		
GLBRC Scale-up	plants		X	X	X	X	X	X	X	X	X	X	X
GLBRC Scale-up	surface soil		X	X	X	X	X	X	X	X	X	X	X
GLBRC Scale-up	microplot surface soil		X	X									
GLBRC Scale-up	deep core soil		X					X					
GLBRC Scale-up	microplot deep core soil		X										
GLBRC MLE	plants											campus	campus
GLBRC MLE	surface soil											X	X
GLBRC MLE	deep core soil						X				X		
GLBRC Switchgrass Gradient	plants			X	X		X		X	X	X		
GLBRC Switchgrass Gradient	deep core soil						X				X		

Agronomic Soil Analysis

Experiment	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
LTER MCSE	X	X	X	X	X	X	X	X	X	X	X	X
LTER Resource Gradient				X						X		
GLBRC BCSE main	X	X	X	X	X	X	X	X	X	X		Gl-3
GLBRC BCSE micro				X	X	X	X	X	X	X		Gl-3
GLBRC BCSE deep core	X					X				X		
GLBRC Scale-up	X	X	X	X	X	X	X	X	X	X		L1, M1
GLBRC MLE						X				X	X	
GLBRC Switchgrass Gradient										X		X