Evaluation of harvest regime and manure application on native prairie plant mixtures grown for ecosystem services and as feedstock for biogas production.

Carol L. Williams[1], Shibu Jose[1], Sougata Bardhan[1], Christine Costello[2], Chung-Ho Lin[1], Teng Lim[3], and Ranjith Udawatta[1].

[1]Center for Agroforestry, University of Missouri; [2]Food Systems and Bioengineering, University of Missouri; [3]Agricultural Systems Management, University of Missouri

Why this work is important to landowners. Interest in production of native perennial herbaceous plants as crops for bioenergy and co-products is driven in-part by sustainability advantages compared to non-native and annual plants. Diverse mixtures of native prairie plants, when carefully managed on agronomically and economically marginal lands, can prevent soil erosion, retain soil nutrients, improve water quality, sequester atmospheric carbon, provide critical wildlife habitat, and provide farm income simultaneously. Individual prairie species [e.g., switchgrass (*Panicum virgatum*)] and combinations of native grasses, forbs and legumes are currently used as commercial-scale feedstock for combustion to produce heat, power and steam, and at pilot scales for production of ethanol and other liquid transportation fuels. A major potential market being explored for mixed native prairie feedstock is anaerobic digestion (AD) to produce biogas and derived liquid fuels and biochemicals. Fermentation and down-stream biological and refining processes for biogas are supported by robust science. However, comparatively less is known about prairie “cropping systems” that maximize biogas potential and ecosystem services simultaneously. Research is needed to understand plant species’ characteristics (physical, chemical) and plant community dynamics that may affect feedstock quality and yields important to biogas production processes and business model sustainability. Potential impacts of plant community change through time, and concomitant changes in biomass yield and potential management interventions, are relatively unknown for AD/biogas. If commercial AD and biogas are to make significant contributions to national renewable transportation fuel goals, land owner productivity goals, rural economic development and agricultural sustainability goals, it is essential to understand how prairie plant mixtures and their management may effect biomass yields, biogas potential, and ecosystem services at multiple scales. A first step towards this understanding is experimental evaluation of species composition, harvest regime, nutrient application and their interactions on biomass quality, biomass yields and ecosystem services within model systems at plot scale.

Relevance to an existing commercial biogas project. Northwestern Missouri is the location of numerous concentrated animal feeding operations (CAFOs) for swine – perhaps the highest density of swine CAFOs in the U.S. This area is the location of a large, multi-phased biogas project currently under development by Roeslein Alternative Energy, LLC (RAE). The project involves multiple above-ground AD structures utilizing effluent from adjacent swine CAFOs. Through a phase-in process, the effluent in each AD reactor will eventually be combined with native prairie biomass harvested from economically-feasible transport distances to each reactor. At full production capacity, RAE’s AD project will require prairie biomass from approximately 200,000 acres annually. A major goal of RAE’s project is improvement of ecosystem services within agricultural landscapes of the project area while achieving economic profitability. To achieve this goal, cool-season grass monocultures (i.e., Tall fescue) and corn/soybean currently grown on marginal lands within the project area are being converted to dedicated prairie mixtures. These “spec mixes” are being purposely designed with the intention to maximize biogas yield and ecosystem services simultaneously (i.e., optimized). Many of the converted fields will continue to be used for treated swine manure disposal. Biomass harvest is planned in a rotation where no field or portion thereof will be harvested more than once in a three year period. For long-term planning it is essential to understand whether the “spec mixes” will over time maintain fidelity to intended/designed species compositions and deliver the intended benefits under harvest and nutrient management conditions expected during the lifespan of the project.

Experiment description. In 2016, a field experiment was initiated to evaluate harvest regime, manure application, and their interactions on biomass yields and ecosystem services of tall fescue and switchgrass monocultures, native prairie mixtures of differing diversity and composition, and fallow. The experiment is being conducted at the Bradford Research Center near Columbia, MO.

The experiment consists of six plant treatments: fescue monoculture (“control”), switchgrass monoculture (due to bioenergy industry emphasis), “low-diversity” prairie mix (9 species; two grasses, six forbs, one legume), “high-diversity” prairie mix (18 species; four grasses, 12 forbs and two legumes), a “low profile” prairie mix (12 species; three grasses, seven forbs and two legumes), and fallow (plants from existing seedbank and recruits from nearby fields). The low- and high-diversity prairie mixes contain switchgrass and other native grass species that are known to be “aggressive” growers that provide a large proportion of biomass but over time can displace native forbs and legumes. Therefore, the so-called “low profile” mix contains less aggressive grasses to potentially reduce loss of forbs and legumes over time. The low-diversity mix is a modification of CRP CP2 mix, where the total number of species has been reduced from 12 to nine. The high-diversity mix is a “feasible high diversity” mix determined by a consortium of subject matter experts familiar with the RAE project. The low-profile mix is entirely novel.

There are three harvest treatment levels: no harvest, annual harvest (after senescence) and green harvest every third year (any time after July 15, according to grassland bird protection protocols).

There are two swine manure treatment levels: none and average rate used by swine operations in the RAE project area. Swine manure will be surface applied once annually, probably in spring.

The experimental design is randomized complete block composed of 36 plots per block, and three replicate blocks. Plots are 2m x 2m. Alleys of 1.6 meter have been placed around all plots/blocks and are mowed regularly during the growing season. Plant mixtures were established June-July (2016) as seedlings (plugs) in a density of 144 plants per plot (plant spacing of 16.5 cm).

The experiment is being conducted in a level, well-drained arable field containing alfisol soils of average fertility for the region. Aggregate soil sampling was conducted in November (2016) and baseline measurements of soil texture, carbon, organic matter, etc., will be conducted within MU facilities during winter 2016-2017. After establishment, observations will be made annually (at various appropriate intervals within years) on species composition, above-ground biomass, below-ground biomass, soil carbon, soil moisture, soil microbial community, soil nutrient cycling, biogas potential (individual species and species mixes), occurrence of invertebrates (species, richness, density, etc.), and the fate of various compounds present in manure. Chemical and physical characteristics of each plant species and each plant mixture will be evaluated annually. Other criteria are under consideration.

Expected outcomes. Findings from our experiment will significantly help Missouri landowners and industry make informed decisions regarding long-term agricultural productivity, energy productivity and sustainability performance (e.g., soil health and carbon balance) of biomass production systems involving native perennial herbaceous plant species. We further anticipate that our results will provide an understanding of farm nutrient cycling (N and P) within the model systems and thus inform decision-making regarding nutrient management in dedicated biomass production systems.

Grant received. This project is being funded in part by a grant from Roeslein Alternative Energy ($49,068).