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Long-Term Assessment of Miscanthus Productivity and Sustainability

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Introduction

Research has consistently shown *Miscanthus* × *giganteus* is among the most productive biomass crop options for the Midwestern U.S. However, because this perennial grass is a sterile hybrid, clonal propagation is required to establish new fields, which is achieved by digging and replanting rhizomes. Despite this challenge, and because of recent advances in planting technology, *M.* × *giganteus* production is economically competitive as a renewable solid fuel.

Recently the University of Iowa (UI) set a goal to substantially increase its sustainability and renewability campus-wide. After close consideration of several options, and a thorough economic analysis, it was determined a large portion of their sustainability portfolio would include *M.* × *giganteus* to co-fire with coal. Today, the UI Biomass Fuel Project has successfully established, maintained, harvested, and co-fired *M.* × *giganteus*. However, increased *M.* × *giganteus* production will be required to meet the UI's sustainability goals.

One challenge to scaling up a project like this is determining the best way to manage *M.* × *giganteus* to balance input costs, yields, and quality. The Biomass Crop Production and Physiology (BCPP) group at Iowa State University has worked to characterize establishment techniques and gather baseline yields using existing best management practices (BMPs). Now, aided by new technology and clear end-user goals, the BCPP group is working to update and improve *M.* × *giganteus* BMPs to keep pace with this rapidly developing industry. To address these needs, the BCPP group has established the Long-term Assessment of *Miscanthus* Productivity and Sustainability (LAMPS) project. This project is dedicated to answering the questions producers and end-users have about BMPs for *M.* × *giganteus*.

Materials and Methods

Statistical design. The statistical design of LAMPS is a randomized block design with a split-plot. The whole-plot treatment is planting year, and the sub-plot treatment is nitrogen (N) fertilizer application rate. Whole-plots are 80 ft x 200 ft and each sub-plot is 40 ft x 80 ft. Nitrogen application rates (0, 100, 200, 300, and 400 lb/acre) are repeated once per planting-year and block combination. LAMPS is a chronosequence study with each planting year (2015, 2016, and 2017) repeated four times.

Field sites. The LAMPS project is replicated across three ISU Research Farms: the Allee Research Farm, Newell; the Sorenson Farm, Boone; and the Southeast Research Farm (SERF), Crawfordsville, Iowa.

Land preparation and herbicide program. Each spring, areas to be planted into *M.* × *giganteus* were tilled to a row-crop seed bed consistency with a combination of discing, field-cultivating, and disc-ripping with appropriate operations occurring at each farm. Harness®, Harness® XTRA, or Prowl® pre-emerge herbicides were applied as close to planting as possible. Approximately one month later, a second application of pre-emerge herbicide, with a differing mode of action than the planting application, was made. If necessary, a broadleaf herbicide labeled for corn (2,4-D or Laudis®) was tank mixed with this pre-emerge application. Additional applications of broadleaf herbicides were made as necessary to ensure a weed-free establishment during the first growing season. For *M.* × *giganteus* in its second growing season, a single application of pre-emerge herbicide was made in the early spring. All herbicide applications were made at the rate suggested for corn growing on the soil type found at each respective location. For *M.* × *giganteus* in its third growing season, it is anticipated no herbicide will be required.

N application. A liquid solution of urea ammonium nitrate (UAN - 28% or 32% depending on the farm) was applied prior to planting using a side-dressing applicator (Figure 1). For *M.* × *giganteus* already planted, nitrogen was applied at the appropriate rate in each subsequent spring prior to emergence.

Plant material and planting. Freedom® *M.* × *giganteus* rhizomes were sourced from REPREVE RENEWABLES, LLC, and a proprietary rhizome planter (Figure 2) was used to plant each site in the spring.

Data collection. Stem densities were measured throughout the first season of LAMPS. Stems were counted at random from several points of known area within each sub-plot to determine stem density. Yields were measured in a similar way. At the end of the growing season, quadrats of stems from a known area were cut at 6-8 in. above the soil surface from each sub-plot. Dry matter yields per unit area were calculated.

Results and Discussion

Stem density. *Miscanthus* × *giganteus* established well at each location. By mid-summer 2016, stem densities had reached 260, 230, and 186 stems$\cdot$ft^{-2} for Allee, Sorenson, and SERF, respectively for the 2015-planted *M.* × *giganteus*. 2016-planted *M.* × *giganteus* was still establishing by mid-summer 2016, so stem densities are not shown. Although N is known to stimulate aboveground growth, 2015-planted *M.* × *giganteus* stem densities were not affected by N rate in 2016 ($P > 0.05$) (Figure 3). Alternatively, one might suggest N-driven aboveground growth may manifest as increasing plant heights; however, on the dates measured, heights were not significantly impacted by N rate (data not shown).

Yields. There was an <u>inconsistent</u> yield response to N fertilizer in the 2015 growing season. At Allee and SERF there were no significant yield responses to N fertilizer ($P > 0.05$). However, at Sorenson there was a clear positive correlation between increasing N rate and final yield ($P < 0.05$) (Figure 4). Our initial hypothesis for this result was that cropping history was driving the N effect as all plots at Sorenson followed corn, whereas all plots at Allee and half of the plots at SERF were following soybean. However, preliminary biomass data from 2016 do not show a significant response to N fertilizer at any location (data not shown).

These inconsistent N responses across location and time are consistent with the conflicting information in the established *M.* × *giganteus* literature. Studies have shown positive and neutral effects of N fertilizer on yield and negative and neutral effects of stand age on yield. These findings have generally been found between different studies at different locations. Here we have found inconsistencies within the same study on the same farms, further emphasizing the need for chronosequence data when assessing *M*. × *giganteus* growth and development.

Acknowledgements

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Figure 1. Side-dresser used for applying liquid UAN to *M*. × *giganteus* plots prior to planting.

Figure 2. Proprietary *M*. × *giganteus* rhizome planter.

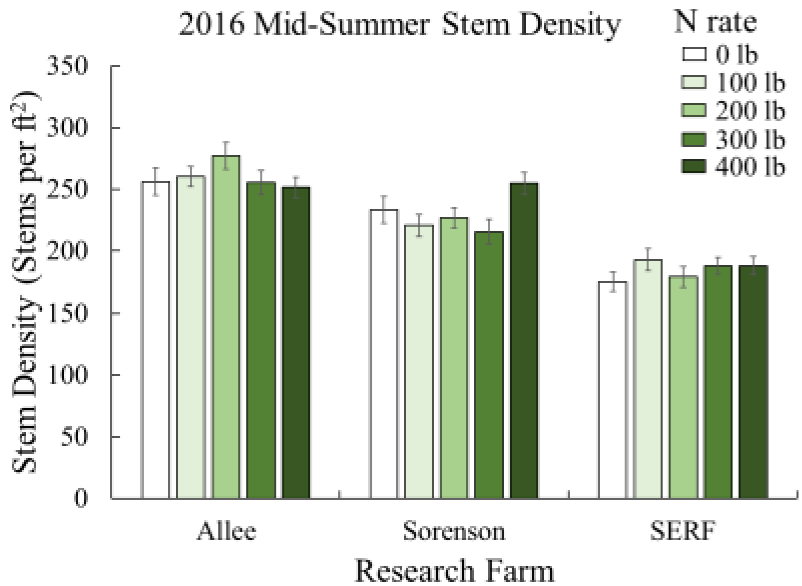

Figure 3. Stem densities measured at each farm using a known area quadrat. Bar height indicates the mean of stem density averaged over blocks (n = 4) and error bars represent the standard error of each mean.

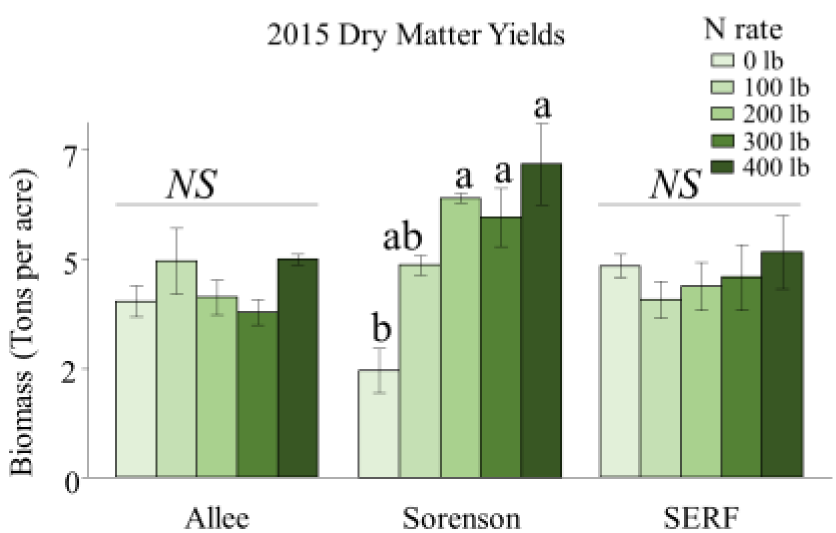

Figure 4. End of season dry matter hand-harvested yields. Stems were cut from a quadrat of known area to a stubble height of 6-8 in. Bar height indicates mean of yields averaged over blocks (n = 4). NS indicates no significant differences within a location. Means indicated by different letters are significantly different at $P < 0.05$. Error bars indicate standard error of the means.