Miscanthus REpeated PLAnting Year (REPLAY) Study

RFR-A18102

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Introduction

Increased awareness of global climate change and an increased desire to reduce CO_2 emissions associated with fossil fuels has driven more interest into biomass crops as a source of energy. *Miscanthus x giganteus* (hereafter, miscanthus), a perennial biomass crop, has demonstrated high biomass yields with relatively low inputs in Midwestern research trials. The potential of this crop motivated the University of Iowa to investigate and begin using this perennial crop as a solid fuel source to generate electricity, heat, and steam. The University of Iowa has set an ambitious goal of achieving 20 percent renewable energy and zero coal use on campus by 2025. A large portion of this goal will be met by converting miscanthus to electricity in their solid fuel boilers. Given the increased marketability and potential of miscanthus in Iowa, more management and yield data are needed to predict the long-term sustainability of this novel crop.

Similar to other perennial crop research, most miscanthus data have been collected from a single stand planted once and followed for several consecutive years—a “single-start” experiment. However, this approach confounds individual growing seasons with stand age, thus being unable to determine if effects on yields change over time because of plant maturity or growing season effects. To uncouple the effects of stand age and growing season, miscanthus was established in three consecutive growing seasons, 2015, 2016, and 2017. This design, known as a Repeated Planting Year (REPLAY) study, allows us to distinguish between the effects of planting season (establishment success), growing season conditions (e.g. drought, ideal, flood), and stand development. Using a REPLAY design, (Figure 1) the Long-term Assessment of Miscanthus Productivity and Sustainability (LAMPS) study was established.

Materials and Methods

Statistical design. LAMPS was established as a randomized complete block design with split-plots. Stand age was represented in the whole plots and were replicated four times. Sub-plots received five different rates of nitrogen (N): 0, 100, 200, 300, and 400 lb of N/acre. Whole plots were 80 ft x 200 ft and each of the sub-plots were 80 ft x 40 ft.

Field sites. This experiment was established at three sites in Iowa: the ISU Allee Research Farm in northwest Iowa, the ISU Sorenson Farm in central Iowa, and the ISU Southeast Research Farm (SERF) in southeast Iowa. These sites represent two degrees of latitude and three degrees of longitude as well as differing soil types and weather conditions.

Data collection. Aboveground biomass was collected annually in winter or early spring depending on weather conditions. At each harvest, two 3.3 ft^2 quadrats/plots were collected using a hedge trimmer. In the 2016 and 2018 harvests, a composite subsample was used to estimate dry matter content. In 2017, dry weight was determined by collecting 15 random stems from each plot. Dry matter was calculated by sub-sampling each quadrat biomass and drying to a constant weight to determine moisture content.

Results and Discussion

Yields. Consistent with previous work, it was found the effect (or lack of effect) of N on miscanthus yield varied across sites, growing seasons, and stand ages. LAMPS, with its REPLAY experimental design, was the first to suggest establishment conditions impact miscanthus yield response to N fertilizer more than geographic location during the yield building phase.

When averaged across all sites and growing seasons, there was a slight trend towards improved yields with increasing N rate. At SERF, this effect was not significant (Figure 2, blue boxes). Considering all sites and growing seasons, miscanthus yields changed with N fertilization approximately one-fifth of the time.

Establishment conditions significantly affected yields. During the 2015 growing season, the amount of precipitation was greater than any of the following years. The 2017 planting year was drier than the 25-yr average at SERF, and the 2016 growing season had an intermediate rainfall total. Across sites, growing degree days (GDD) ranged from 2,300 to 3,000, but SERF consistently received more GDD than the central and northwest sites. The length of growing season also varied across the sites ranging from 165 to 200 days with no clear pattern across the sites or years.

All stands increased their yields during the first three years of development. At SERF, yield followed a similar trajectory to the Sorenson Farm, where yield increased linearly with age. These trends were not affected by N rate.

Acknowledgements

We thank Cathi Hunt, Valeria Cano-Camacho, and Collin De Graaf for their help on designing the experiment, data collection, and processing; and Lyle Rossiter, Mike Fiscus, Myron Rees, and support staff at the research farms for their support with on-farm management and data collection. This project was funded by USDA National Institute of Food and Agriculture Hatch grant; the Leopold Center for Sustainable Agriculture; the Iowa Energy Center; the Iowa State University Department of Agronomy; and U.S. Department of Energy, Office of Science, and Office of Biological and Environmental Research.

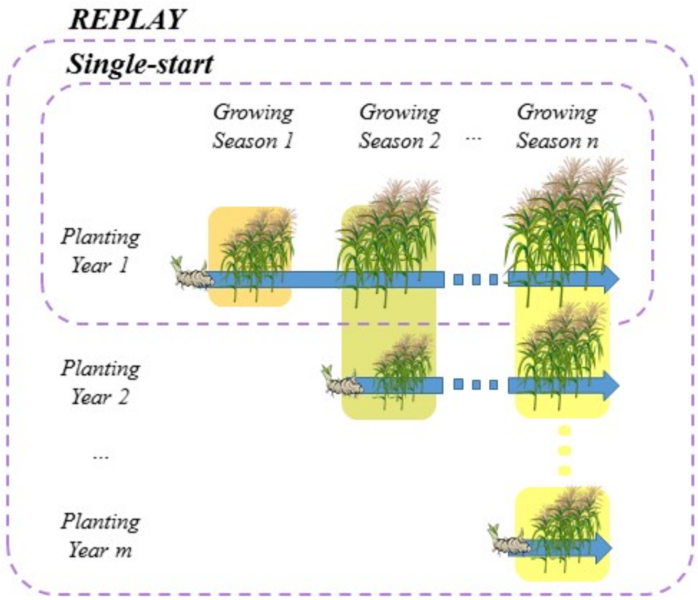

Figure 1. Schematic representation of single-start and REPLAY designs for the study of perennial crop.

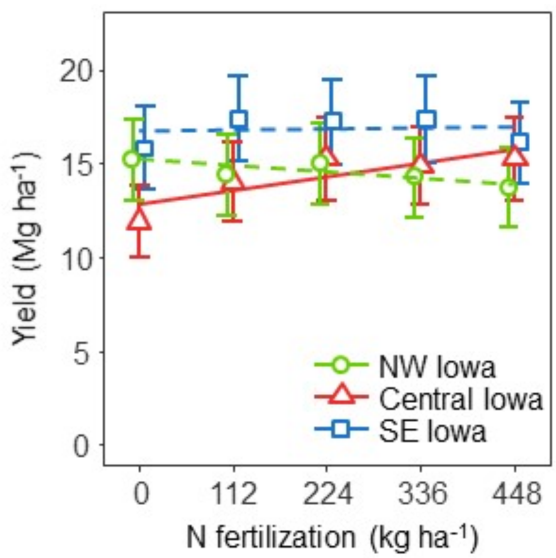

Figure 2. Miscanthus x giganteus yield response to nitrogen fertilization at three sites across Iowa using a (REPLAY) experimental design. Values are averaged over stand ages and averaged over three growing seasons (2015-2017). Dashed lines indicate non-significant responses and solid lines indicate significant ($P < 0.05$) responses. Vertical bars indicate the 95% confidence interval; non-overlapping intervals indicate significantly different means across sites or stand ages ($P < 0.05$).