Investigating alternative fertilizers for herbaceous biomass crops grown in southern Ontario to improve yields and soil health

Sarah Hasenack* (MSc student, University of Guelph), Dr. Kari Dunfield, and Dr. Naresh Thevathasan

Introduction

Biomass Crops are perennial crops grown to harvest their aboveground biomass for use in various value-added industries, including bio-products, bio-energy (combined heat and power), animal bedding, soil mulch, and more.

Switchgrass (*Panicum virgatum*) and **miscanthus** (*Miscanthus x giganteus*) are two herbaceous biomass crops commonly grown in Ontario

Benefits and Services
- Sustainable products
- Successful on marginal land
- Environmental benefits (soil, water, and climate change)

Switchgrass at the Guelph Turfgrass Institute in Guelph, ON (August, 2019).

Challenge: To Improve Yields
- Inorganic nitrogen (N) fertilizer has increased yields in both species, but are associated with negative environmental impacts
- Further yield increases are required to achieve competitive pricing for biomass products

Miscanthus at a farmer's property in Milton, ON (July, 2019).

Alternative Fertilizer Options
1. Biosolids: treated municipal sewage
2. Biofertilizers: inoculants of beneficial microbes

Goals

Study Goal: Compare the effects of five different fertilizer treatments, including one biosolids-based organic fertilizer and two biofertilizers, on (1) plant growth and yield and (2) soil health under field conditions for switchgrass and miscanthus in southern Ontario.

Long-term Goal: Contribute to informing future best-management recommendations for biomass crop producers in Ontario.

Experimental Design

Design: All treatments were applied in a complete randomized block design at 3 field sites (one research site and two farmer's properties) with 3 or 4 replicates per site.

Treatments: (1) control – no inputs, (2) chemical fertilizer – crop-specific rates of chemical N (60 kg N/ha), (3) LysteGro – biosolids applied according to recommended N rates, (4) JumpStart® – biofertilizer for P-solubilizing fungus, *Penicillium bilaiae*, with a ½ rate of N, and (5) MYKE® Pro – biofertilizer for arbuscular mycorrhizal fungus *Glomus intraradices*, with a ½ rate of N.

Map of the experimental design at the research field site used for this trial: the Guelph Turfgrass Institute (GTI).

Colour Guide: grey = control, red = chemical fertilizer, green = LysteGro, yellow = JumpStart®, blue = MYKE® Pro

Plant Growth and Yield

Components
1. Plant Growth Curves were created to assess effects on individual plant growth
2. Final Yield and Tiller Counts were quantified assess effects on yields which affect profits

Biweekly plant sampling day at the switchgrass farmer's property in Milton, ON (August 2019).

Methods: Final Yield and Tiller Count
- In November, 2019, biomass crops were harvested from an area of 0.25m^2 (0.5 m by 0.5 m)
- Statistical analysis was performed to determine if any fertilizer caused significant changes in yields or tiller density
- Linear regression to test the relationship between tiller density and yield was also conducted

Methods: Plant Growth Curves
- Biweekly sampling of 5 randomly selected plants per plot (treatment day to late October, 2019)
- Measurement of plant height, leaf number, leaf area, and dry weight of stems, leaves, and full plant
- Model comparisons to check for significant effects of each fertilizer on individual plant growth

Final yield (and soil) sampling at the Guelph Turfgrass Institute field site (November, 2019).

Soil Health

Components
1. Soil Fertility: assessed treatment effects on nutrient availability for plant uptake
2. Soil Microbial Communities: assessed treatment effects on bacterial and fungal abundance
3. VitTellus Soil Health Score: a comprehensive soil health score as determined

Summary of sampling times for each component.

Component	Sampling Time(s)		
	Pre-treatment	Mid-season	End of Season
Fertility	✔		✔
Microbial	✔	✔	✔
Soil Health			✔

Methods: Fertility
- Two random 30 cm-deep soil samples were taken from each plot to assess macronutrient levels
- Plant tissue samples were taken at peak season (early August, 2019) to quantify plant uptake of nutrients

Methods: Microbial Communities
- Composite of eight 10 cm-deep soil samples in an x-formation across each plot
- Extract DNA and use qPCR to quantify the bacterial and fungal communities

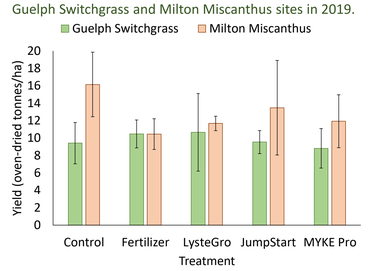
Methods: VitTellus Soil Health Score
- 30 cm-deep soil sample at a random location in each plot
- Sent to A&L Canada Laboratories for analysis and calculation of VitTellus soil health score

Baseline soil microbial sampling at the miscanthus farmer's property in Milton, ON (July, 2019).

Results and Current Progress

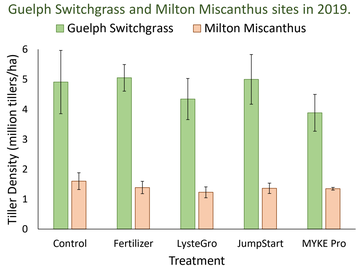
Yield
- No significant differences among treatments at the Guelph Switchgrass and Milton Miscanthus sites (p = 0.846 and p = 0.341, respectively)

Average yields (with standard deviation bars) at the Guelph Switchgrass and Milton Miscanthus sites in 2019.

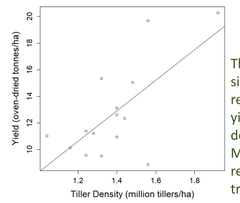


Tiller Density
- No significant differences among treatments at the Guelph Switchgrass and Milton Miscanthus sites (p = 0.178 and p = 0.279, respectively)

Average tiller density (with standard deviation bars) at the Guelph Switchgrass and Milton Miscanthus sites in 2019.



Tiller-Yield Relationship
- No significant relationship between tiller density and yield at the Guelph Switchgrass site (p = 0.2181)
- Significant positive relationship between tiller density and yield at the Milton Miscanthus site (p = 0.0056)



This graph shows the significant positive relationship between yields and tiller density at the Milton Miscanthus field site, regardless of fertilizer treatment.

Note: No yield or tiller data available for the third site (Milton Switchgrass) due to miscommunication leading to crop harvest before data could be collected. Analysis of plant growth curves and soil health data is ongoing.

Significance

Scientific: Improve understanding of different types of fertilizers' responses on soil health and biomass yields

Environmental: Recommend the best fertilizer types for Ontario-grown biomass crops in order to enhance soil health and reduce negative environmental impacts

Policy: Inform best management recommendations and policies

Economic: Promote a thriving and sustainable biomass economy in Ontario

Note: final conclusions regarding scientific, environmental, policy, and economic significance of this study will be made at the end of the second field season (2020).

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*To contact the researchers, please email Sarah at shasenac@uoguelph.ca.

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