Sorghum growth and development in soils from different switchgrass fields is altered by the presence of an intact soil microbial community

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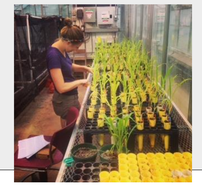


Introduction

Swichgrass (*Panicum virgatum*) is a popular candidate biofuel in the USA, however, little is known about its relationship with belowground microbial communities. This includes the relationships between switchgrass and arbuscular mycorrhizae (AMF), fungi that live symbiotically with plant roots.

Where nitrogen and phosphorus are limiting for plant growth, the benefit of association with mycorrhizae is large (Hetrick et al., 1989). However, biofuel crops are commonly fertilized. The potential for changes in microbial communities following fertilization and the effect of this on plant performance is not well understood. Fertilizer can replace the nutrients obtained by mycorrhizae, leading to similar productivity in fertilized and unfertilized fields.

Different susceptibility of plant species and varieties to parasitism can also affect the abundance of AMF and the benefits of symbiosis (Grman 2012). Due to the above, it is important to understand how microbial communities and fertilization interact to determine how fertilizers can be best used to enhance productivity of biofuel crops.

Research Questions

1) **How does the presence of living soil communities from switchgrass fields affect growth and development of a C4 grass?**
2) **Do these effects differ between switchgrass varieties or fertilized and unfertilized fields?**
3) **Are plants grown with different inoculum colonized by AMF at different rates?**

Methods

Soil samples from fields with different varieties of switchgrass (Cave-in-Rock and Southlow) and with or without fertilizer were collected from the Kellogg Biological Station's LTER Cellulosic Biofuel Plots in June, 2014. Half of the soil from each of the four treatments (variety & fertilizer) was sterilized using an autoclave (1 hr @ 121°C, 2x).

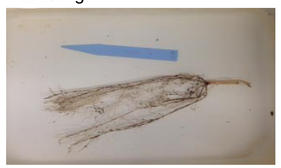
In the greenhouse, 10 mL from each soil treatment was placed in a conetainer containing potting soil (10% inoculum by volume) and seeded with sorghum. Sorghum is a fast-growing grass that has a similar physiology to switchgrass (C4 photosynthesis). Individuals were harvested after 25 days. After harvest, aboveground biomass was oven dried (72h @ 55°C) and weighed.



Methods (cont.)

Roots were washed to remove soil (see images). We then measured the total wet weight of roots. Between 0.1 and 0.2 g was removed from each plant for measuring AMF. The remainder of the roots were dried and weighed as with aboveground biomass. Total dry weight of all roots was determined using % moisture of the sample.

We cleared the roots in 10% KOH, then stained them in a 5% ink-vinegar solution. The presence of fungal structures (hyphae, vesicles, arbuscules, spores, etc.) were counted at 100x magnification for 100 random intercepts covering 10 cm of root length.


Results

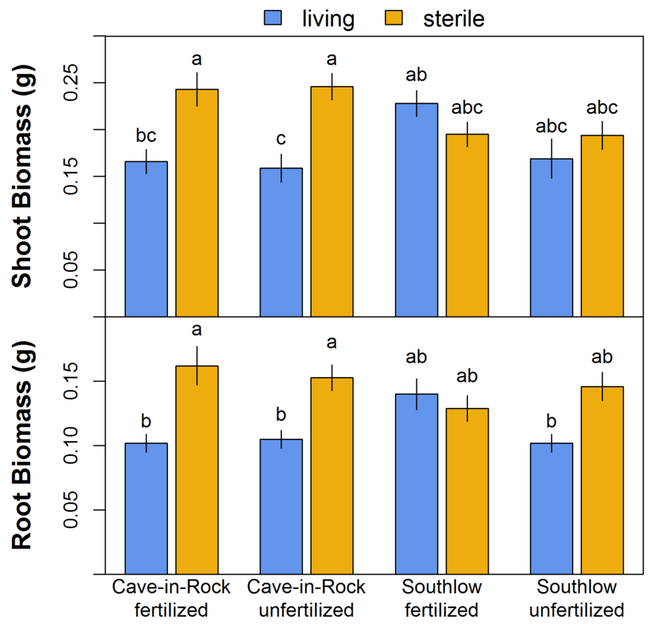


Figure 1 – Sorghum plants inoculated with soils from Cave-in-Rock switchgrass grew produced more aboveground biomass when soils were autoclaved (ANOVA variety * inoculum: $F_{1,149} = 16.65$, $p < 0.001$). Similarly, root biomass was significantly greater for sorghum grown in sterile soil from both types of Cave-in-Rock soil and unfertilized Southlow soil (ANOVA variety * inoculum * fertilizer: $F_{1,149} = 5.11$, $p = 0.025$). For both panels means ± SE are shown, and letters indicate differences according to *post-hoc* Tukey Honest Significant Difference.

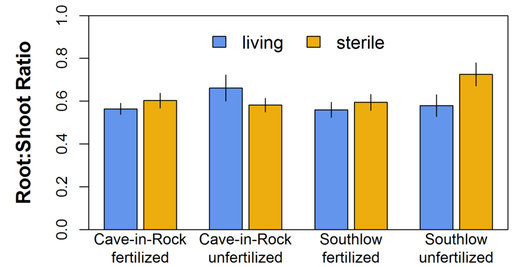


Figure 2 – Root shoot ratio did not differ among the soils, although there was a trend toward a difference between living and sterile for the Southlow, unfertilized soils (ANOVA variety * inoculum * fertilizer: $F_{1,149} = 3.49$, $p = 0.064$).

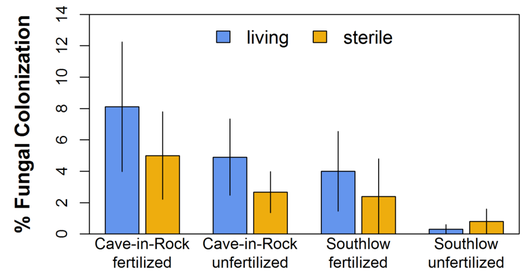
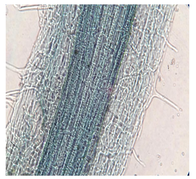
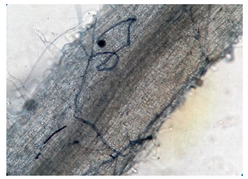
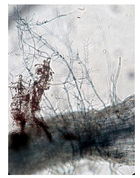
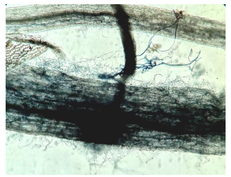


Figure 2 – Colonization by fungi was low and highly variable. (N = 5-10 samples for each treatment). The high variation led to no significant differences between soils, but plants from Cave-in-Rock fertilized had the highest colonization, and Southlow unfertilized the least.

Conclusions

- Sorghum in 'sterile' soils had improved above- and belowground growth (FIG 1), especially from Cave-in-Rock fields.
- Fertilizer only had an impact on plants in soils from Southlow fields (FIG 1,2).
- All plants had some fungal colonization in the roots, including those in 'sterile' soils (FIG 3). Many were likely saprophytes or parasites, given the scarcity of AMF structures .
- Poor relative performance of sorghum in 'live' Cave-in-Rock soils could be related to higher fungal abundance, esp. if many were non-mycorrhizal.
- Microbial community not always beneficial to plants; in LTER Cellulosic Experiment there may be many parasitic microbes.
- Agriculture can leave large legacies on microbial community, inoculation with "wild" soils from prairies or older fields of *Panicum* could increase AMF.
- Alternatively, AMF may need longer than 25 days to colonize roots in greenhouse. Future work will examine this.

Acknowledgements & References

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