Perenniality Drives Soil Microarthropod Community Differences Across Three Potential Bioenergy Cropping Systems

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Project Goals: The goal of this project is to understand how bioenergy crop identity and management influence microarthropod community structure. This work is part of a larger project investigating microarthropod-microbe interactions and their effects on soil carbon accrual.

Abstract text: As Bioenergy with Carbon Capture and Storage (BECCS) continues to show promise as an effective carbon mitigation strategy, bioenergy cropping systems are predicted to become increasingly prevalent in coming decades (Rogelj et al., 2018). Despite its potential as a sustainable alternative to fossil fuels, the widespread implementation of BECCS remains hindered by uncertainties about the ability of bioenergy cropping systems to accrue soil organic carbon (SOC). Specifically, there are serious concerns that the conversion of marginal, non-agricultural lands to managed agroecosystems for bioenergy crop production may result in substantial SOC loss. Before BECCS can be utilized to help offset global emissions and prevent further climate warming, there must be greater understanding of the processes driving SOC accrual and long-term storage in selected bioenergy cropping systems.

While SOC dynamics were traditionally thought to depend primarily upon plant chemistry, it is increasingly understood that soil biota, especially microbes, play a critical role in SOC formation and stabilization (Kallenbach et al., 2016). However, the potentially significant effects of soil fauna on SOC accrual remains unclear. Microarthropods (mites and collembola) are the most abundant and diverse arthropods in soils across ecosystems. Primarily detritivorous and/or microbivorous, microarthropods affect SOC by physically and chemically altering plant litter as well as influencing microbial activity, abundance, and community composition, with potentially important consequences for SOC accrual. When microarthropods, especially mites, were experimentally suppressed, slowed early-stage litter decomposition resulted in 11% less SOC accrual in tallgrass prairie soils based on DayCent modeling (Soong et al., 2016). However, understanding the role of these interactions in the context of bioenergy cropping systems is complicated by the strong impacts of land use and management on microarthropod communities. Therefore, it will be necessary to first understand how crop type and management affect microarthropod communities before attempting to investigate their potential role in SOC accrual in bioenergy cropping systems.

We conducted microarthropod surveys from three bioenergy cropping systems differing in crop life cycle, diversity, and management: an annual monoculture (energy sorghum), reduced-input

perennial monoculture (switchgrass), and no-input perennial polyculture (restored prairie). Microarthropods were collected from soil cores (2018 and 2019) and litter quadrat samples (2019) at three sampling stations within each of five replicate plots (n=15 per treatment) and extracted using Tullgren funnels. Major microarthropod group abundances were counted, with oribatid mites and collembola further categorized to morphospecies to evaluate differences in community composition across cropping systems. We find strong evidence that perennial bioenergy cropping systems support the highest microarthropod abundances. Mites were consistently more abundant in both perennial systems while collembola were as or most abundant in the annual monoculture. Ordination of microarthropod community structure showed that communities in the perennial systems were more similar to each other than the annual monoculture, which was distinct. By supporting greater microarthropod abundances, particularly of mites, this study adds to the growing body of evidence indicating the increased sustainability of perennial bioenergy cropping systems relative to annual systems and is the foundation of ongoing studies evaluating the impact of microarthropods on microbial function and physiology likely to strongly influence SOC dynamics.

References/Publications

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