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Effects of soil microbial community variability on *Silphium integrifolium*, *Lespedeza capitata*, and *Andropogon gerardii* growth

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ABSTRACT

The complex interactions between biodiversity and plant production have been researched for decades by the scientific community. Ecologists previously believed that species coexistence was determined by competition for available resources, however, new evidence indicates that the soil microbial community is one of the main driving forces for coexistence. Research has shown the vital role of the soil microbiome for providing a rise in plant yield. In this study, three species native to Kansas were grown in differing soil treatments to determine how the soil microbial community affects plant growth. Many of the response variables that we measured were not significantly different among *Silphium integrifolium, Lespedeza capitata*, and *Andropogon gerardii*. Across the three species, only *Silphium* showed a significant difference in above and below biomass for the control soil treatment compared to the other soil treatments. There is still more research needed to fully understand how soil microbial communities affect plant productivity and plant species richness.

Keywords: *Silphium integrifolium*, *Lespedeza capitata*, *Andropogon gerardii*, soil community, soil pathogens, plant-soil interactions

INTRODUCTION

One of the scarcest ecosystems in the United States are tallgrass prairies (Knapp, et al., 1997). In the US there has been a decline in remnant prairie land because the vast majority of prairie land has been converted to raise crops. There are many reasons to preserve prairie land because of the long-term benefits for the ecosystem. Prairie restoration is often done in response to prairie land that had a decrease in habitancy, loss of biodiversity, or in response to the prairie land having been converted for agricultural use (Knapp, et al., 1997). Research has shown that conserving grasslands will support an ecosystem's productivity in the long run due to the fact that a diverse plant community is better equipped to survive a natural disaster, such as drought (Tilman and Downing, 1994).

The soil microbiome plays a key role in plant growth (Bever, et al. 2015). Research has shown how important soil microbial communities are to the productivity of plant species. A study done with arbuscular mycorrhizal fungi (AM) inoculated soil showed its benefits in native plant restoration (Koziol, et al., 2018).

The biotic components of a plant's soil community is not only vital to a plant's longevity, but is also a driving force for productivity (van der Putten, et al., 2013). Positive plant-soil feedback is when the growth of a species is promoted by soil that was previously inhabited by the same species, while in negative plant-soil feedback the soil community impedes species growth (van der Putten, et al., 2013). Further research on plant-soil feedbacks is needed in order to improve plant restoration and plant community productivity.

Three prairie plant species that are native to Kansas are *Lespedeza capitata*, *Silphium integrifolium*, and *Andropogon gerardii*. *Lespedeza capitata* is a round-headed bush clover that is a part of the legume family (Tix and Charvat, 2005). *Silphium integrifolium* is a perennial sunflower that is a part of the aster family (Vilela, et al., 2020). *Andropogon gerardii* is a tall grass species that is commonly called big blue stem (Kramer, et al., 2018). This research will look specifically at how the soil microbial communities of these three species affect plant productivity.

MATERIALS AND METHODS

The purpose of this experiment was to determine how soil microbes affect the growth of prairie plants native to Kansas. The materials used for soil preparation are three prairie soil treatments (soil from the rhizosphere of each of the three species); background/control soil sterilized by autoclaving at 121°C for 3 hours; and sterile potting soil for cold stratification and seed germination. The prairie soils were collected from The Land Institute, in Salina, where these three plants species have been growing for several years. The amount of seeds used were 12g of *Silphium integrifolium*, 3.5g *Lespedeza capitata*, and 1.5g *Andropogon gerardii*. All materials other than the soils were provided by Dr. James D. Bever, Department of Ecology and Evolutionary Biology, Kansas University.

For the first stage, the seeds were placed in a cold and moist atmosphere to overcome embryonic dormancy (Hopkins and Gravatt, 2019). The seeds were placed in planting trays with damp potting soil and placed in a refrigerator at 4°C in order to undergo cold stratification. The three trays were placed in a

plastic bag, to ensure they were in a moist environment for the duration of this stage. The process of cold stratification took place in the beginning of January. In the third week of January, the trays were placed in the greenhouse and watered daily until germination. A few environmental factors that play a key role in the success of germination are temperature, light, and moisture (Vercellino et al., 2019). It is crucial these three elements are satisfied to guarantee germination.

The next stage took place in the third week of February. The plants were transferred from the germination trays into individual groove tubes filled with three parts sterilized background soil and one part prairie soil treatment. There was a total of 48 tubes for each of the plant species, 12 with each of the three prairie soil treatments, and 12 with sterilized soil only as the control. At the start of May the plants were taken to the greenhouse at The Land Institute. The plants spent the summer in a climate-controlled environment and were watered one to two times daily.

In September the plants were transferred back to McPherson College. The height from the ground level to the tip of the longest leaf or stem was measured. The aboveground biomass was dried at 105°C for 2 days and then weighed to the nearest mg. Similarly, the belowground biomass was separated from the soil, dried and weighed. The data were analyzed using a two-way analyses of variance, and the Holm-Sidak procedure for Pairwise Multiple Comparisons with an overall significance level α = 0.05.

RESULTS

A two-way ANOVA comparing soil treatment to plant species' root:shoot ratio, found that there was no significant relationship (see Table 1 and Figure 1; P=0.957).

Table 1. ANOVA table for the effect of differing soil treatments on the root:shoot ratio of *Silphium integrifolium*, *Andropogon gerardii*, and *Lespedeza capitata*.

Source of Variation	df	Mean Square	F	P
Soil	3	0.0548	0.104	0.957
Plant Species	2	20.689	39.403	<0.001
Soil x Plant Species	6	0.122	0.232	0.965
Total	128	0.815		

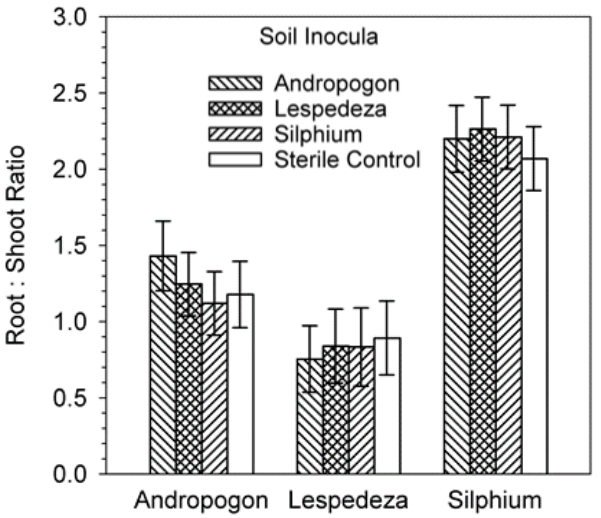

Figure 1. Root:shoot ratio of *Andropogon*, *Lespedeza*, and *Silphium* when grown in differing soil treatments.

There was a significant difference between the total biomass of *Silphium* grown in soil inoculum compared to *Silphium* grown in the sterile control soil (see Table 2 and Figure 2).

Table 2. ANOVA table for *Silphium integrifolium*, *Andropogon gerardii*, and *Lespedeza capitata* total biomass grown in four different soil treatments.

Source of Variation	df	Mean Square	F	P
Soil	3	1.022	1.697	0.172
Plant Species	2	42.070	69.807	<0.001
Soil x Plant Species	6	0.256	0.424	0.862
Total	128	1.259		

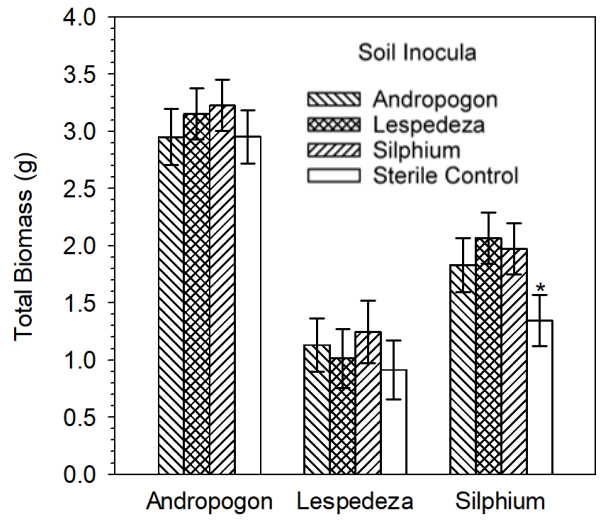

Figure 2. Total biomass of *Andropogon*, *Lespedeza*, and *Silphium* when grown in differing soil treatments.

There was a significant difference between the belowground biomass of *Silphium* grown in soil inoculum compared to *Silphium* grown in the sterile control soil (see Table 3 and Figure 3).

Table 3. ANOVA table for belowground dry mass of *Silphium integrifolium*, *Andropogon gerardii*, and *Lespedeza capitata*.

Source of Variation	df	Mean Square	F	P
Soil	3	0.341	1.216	0.307
Plant Species	2	14.016	49.914	<0.001
Soil x Plant Species	6	0.138	0.493	0.813
Total	128	0.495		

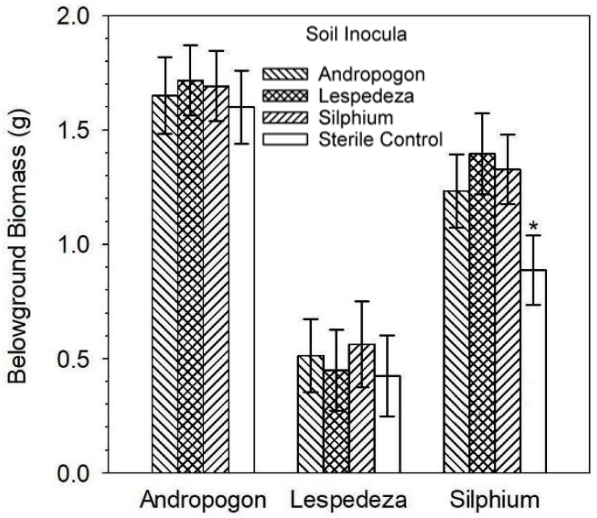

Figure 3. Belowground biomass of *Andropogon*, *Lespedeza*, and *Silphium* when grown in differing soil treatments.

A two-way ANOVA revealed that species aboveground biomass was not affected by the soil treatments (see Table 4 and Figure 4; P=0.189, indicating no significant effect).

Table 4. ANOVA table for aboveground dry mass of *Silphium integrifolium*, *Andropogon gerardii*, and *Lespedeza capitata*.

Source of Variation	df	Mean Square	F	P
Soil	3	0.202	1.619	0.189
Plant Species	2	9.677	77.756	<0.001
Soil x Plant Species	6	0.0395	0.318	0.927
Total	128	0.275		

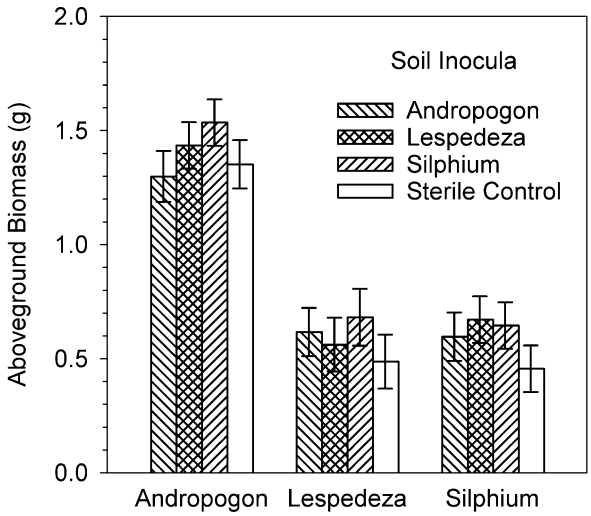

Figure 4. Aboveground biomass of *Andropogon*, *Lespedeza*, and *Silphium* when grown in differing soil treatments.

DISCUSSION

The soil microbial community composition had no direct effect on the root:shoot ratio or the aboveground biomass. There was a significant increase in total biomass and belowground biomass of *Silphium* grown in soil inoculum compared to *Silphium* grown in sterile soil. Based on research conducted in the past, it was expected that the soil treatments containing plant pathogens would significantly affect species growth compared to the sterile soil treatment (Bever, et al., 2015). The results do not fit theoretical predictions that soil microbial communities promote species productivity, with the exception of the total biomass and belowground biomass of *Silphium*. Therefore, it cannot be concluded from this study which soil inoculum best promotes growth of *Andropogon*, *Lespedeza*, or *Silphium*.

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