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Control of Soil-Borne Disease of Soybean

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Cover Page Footnote

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Control of Soil-Borne Disease of Soybean

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Summary

Soil-borne diseases are a significant cause of reduction in crop yield. Alternative management of soils can enhance the natural disease-controlling organisms in the soil. This study explores the impact of alternative production methods on a primary soybean disease, charcoal rot, caused by the fungus *Macrophomina phaseolina*. Treatments that could potentially enhance or control the disease were implemented, and soil tests were conducted for nutrient and disease presence. Manure increased the nutrient levels in the soil, as expected, but did not impact the disease control. Solarization increased the temperature within the plots, and increased the number of colony forming units of *M. phaseolina*. Environmental conditions during the 2022 growing season were much hotter and drier than normal, leading to reduced soybean yields.

Introduction

Suppressive soils have been defined as soils that can inhibit the growth of naturally occurring soil-borne diseases. These soils are capable of suppressing or controlling disease-causing organisms, including fungi (e.g. *Fusarium virguliforme,* cause of sudden death syndrome, SDS), *Macrophomina phaseolina* (cause of charcoal rot), Phytophthora root rot (*Phytophthora sojae*), and nematodes (e.g., soybean cyst nematode, *Heterodera glycines*). How the native soil microbial communities reduce disease is not known. Knowledge of factors that contribute to and support these beneficial microbial communities is also unknown.

One example of this natural improvement in soil microbial community reducing disease was demonstrated in our previous research (Sassenrath et al., 2017, 2019) that demonstrated that a high-glucosinolate mustard (*Brassica juncea*) reduced fungal populations that caused charcoal rot in soil and in soybean plants. Here, we expand on those results by exploring the interaction between soil health and disease pressure. Management practices that increase, decrease, or maintain disease pressure were tested in field studies to determine the impact on soil health, fungal pathogen presence, and soybean growth and yield.

Impact of Soil Health on Soybean Disease

Crop plants that are disease hosts increase the number of disease-causing organisms in the soil. We have previously shown the increase in colony forming units (CFU) of *M. phaseolina* in the soil after soybean production (Sassenrath et al., 2019). Other factors

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reduce soil-borne diseases include high-glucosinolate mustard as a cover crop (Sassenrath et al., 2017, 2019) and increasing the soil temperature (e.g., "solarization"). Use of animal manures greatly increases the diversity of the soil microbial community, and beneficial microorganisms in particular. In addition to improving the soil nutrient balance, manure may contribute to reduced disease pressure (Graham et al., 2014) and soybean cyst nematode populations (Bao et al., 2013).

Diseases are primary factors that reduce the yield and quality of soybeans in Kansas and throughout the world. Soil-borne diseases are prevalent in eastern Kansas crop fields. Certain plants have been shown to produce chemicals that act as biofumigants that control or reduce harmful soil fungi. Animal manures have also been used to alter the soil microbiome to improve the control of disease organisms. Our working hypothesis is that improving the overall soil health by supporting healthy soil microbial communities can reduce disease pressure. Creating suppressive soils by altering management practices will reduce disease pressure. This research explores the relationship between soil health and disease pressure. The research tests the ability of cover crops, animal manure, and solarization to control or reduce charcoal rot in soybean production through improved soil microbial communities.

Experimental Procedures

Replicated plots were established at the Southeast Research and Extension Center in Parsons during the spring of 2022. Plots included: fallow, mustard cover crop, soybean, corn stubble, cow manure, and plastic sheets. Temperature sensors (Hobo, Onset, Inc., Bourne, MA) were installed at 2-in. depth in the soil in plots of one replication and temperatures were recorded continuously. Plastic sheets provide a "solarization" treatment, increasing soil temperature and potentially reducing soil microbes. Corn stubble was spread to about a 2-in. layer; corn stubble provides more carbon for soil microbes, increasing their abundance, but may also act as a host for *M. phaseolina*. Animal manure provides an additional food source for the microbes and adds additional microbes to the soil; manure has been shown to reduce some pathogens in soil. Mustard cover crop has been shown to reduce the number of CFUs of *M. phaseolina*, while soybeans are a host and increase the CFUs of *M. phaseolina*. The fallow treatment was left unplanted and served as a control.

Soil samples were collected in spring prior to implementing treatments, mid-season, and after harvest. Soils were analyzed for nutrients at the K-State Soil Testing Lab, for microbial activity and "Soil Health Score" at Ward Labs (Lincoln, NE), and for the number of CFUs of *M. phaseolina* in the Department of Plant Physiology at Kansas State University.

Results and Discussion

Nutrients changed in response to treatments (Table 1). As anticipated, the cow manure treatment had the highest levels of organic matter (OM), potassium (K), and phosphorus (P). This treatment also led to the highest Soil Health Score. Surprisingly, the solarization treatment (plastic film) had the highest total nitrogen (N) and microbiologically active carbon.

Interesting differences were observed in the environment within the soil in the different treatments (Figure 1). The plastic sheets (yellow line) raised the temperature more than 10 degrees above the fallow treatment (blue line), and temperatures remained elevated at night. Animal manure (grey line) also raised the daytime temperature, but temperatures decreased at night to that of fallow. Temperatures under corn stubble (orange line) were much lower throughout the day compared with the soil temperatures under fallow.

The only statistically significant difference in the number of CFUs was recorded in the solarization treatment (Figure 2), which showed a buildup in CFUs of *M. phaseolina* during the growing season. The corn stubble, cow manure, and soybean treatments had very similar levels of CFUs. The number of CFUs decreased slightly in the fallow and mustard seed treatments.

The summer growing season of 2022 was challenging for crop production due to high temperatures and low rainfall (Sassenrath et al., 2023). Crop establishment in the plots (mustard seed and soybeans) was impaired due to insufficient rainfall. Average yields for plots were very low (~5 bu/a) and well below the 12-year average at the station (Figure 3). Overall, statewide soybean yields were below average.

Conclusions

The soil microbiome controls many of the functions of the soil. It is possible, through alternative management practices, to alter the soil microbiome to support helpful organisms, such as arbuscular mycorrhizae, while controlling disease-causing organisms. Preliminary evidence from this study showed a minor change in microbial composition and activity with treatments. However, the unusually hot and dry weather may have compromised the results, as soybean yields were greatly reduced.

Acknowledgments

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Table 1. Changes in soil nutrients with treatment

	Organic matter, %	Potassium, ppm	Mehlich P, ppm	Total N, ppm	Soil health score	Microbially active carbon, %
Mid-season						
Corn stubble	1.9	74.5	23.0	13.4	9.6	47.6
Cow manure	2.4	150.5	47.3	16.1	13.4	54.3
Fallow	2.0	66.8	18.5	13.2	10.3	48.8
Mustard seed	2.1	78.5	23.0	15.6	12.0	42.8
Plastic film	2.0	62.3	19.5	21.2	13.9	64.9
Soybeans	2.0	73.8	20.3	12.9	11.7	53.1
At harvest						
Corn stubble	2.0	80.3	27.3	19.6	10.4	36.7
Cow manure	2.2	160.3	53.0	27.8	13.2	43.3
Fallow	2.0	60.8	25.8	20.1	12.1	63.4
Mustard seed	2.0	74.5	29.0	21.8	15.3	73.4
Plastic film	2.0	60.3	29.0	33.3	12.1	91.0
Soybeans	2.0	71.8	25.5	19.2	14.1	68.4

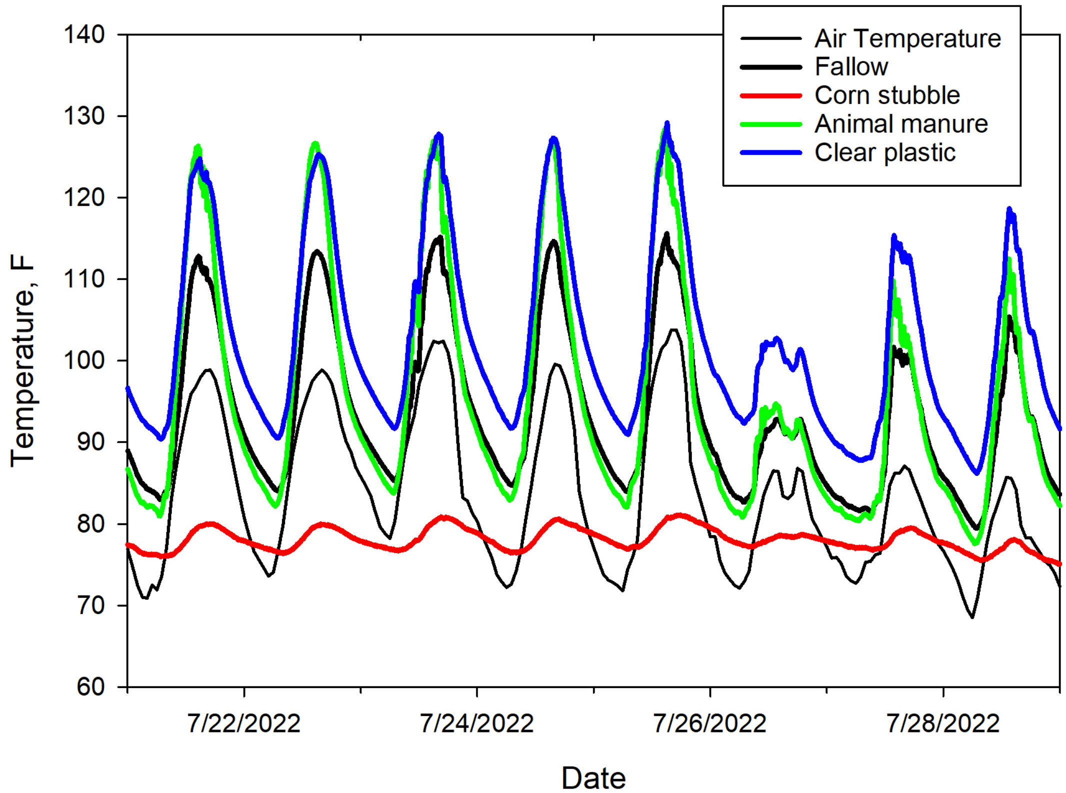

Figure 1. Temperatures (°F) at 2-in. soil depth in the different treatments.

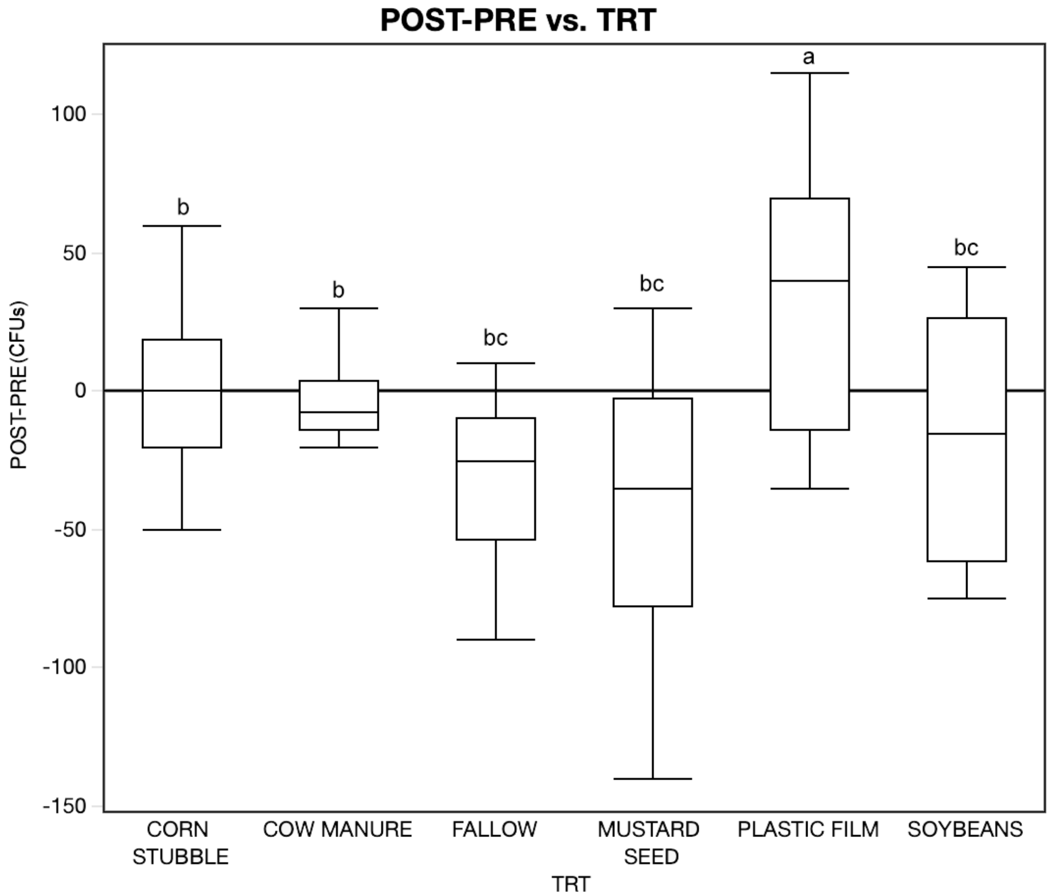

Figure 2. Change in the number of colony forming units (CFUs) of *Macrophomina phaseolina* from prior to planting to at harvest. The line in the middle of the box plots is the median yield of all varieties. The upper and lower quartiles are given by the upper and lower edges of the boxes. The maximum and minimum values are given by the upper and lower "whiskers" extending from the box. Letter values above the whiskers indicate the statistical differences between populations.

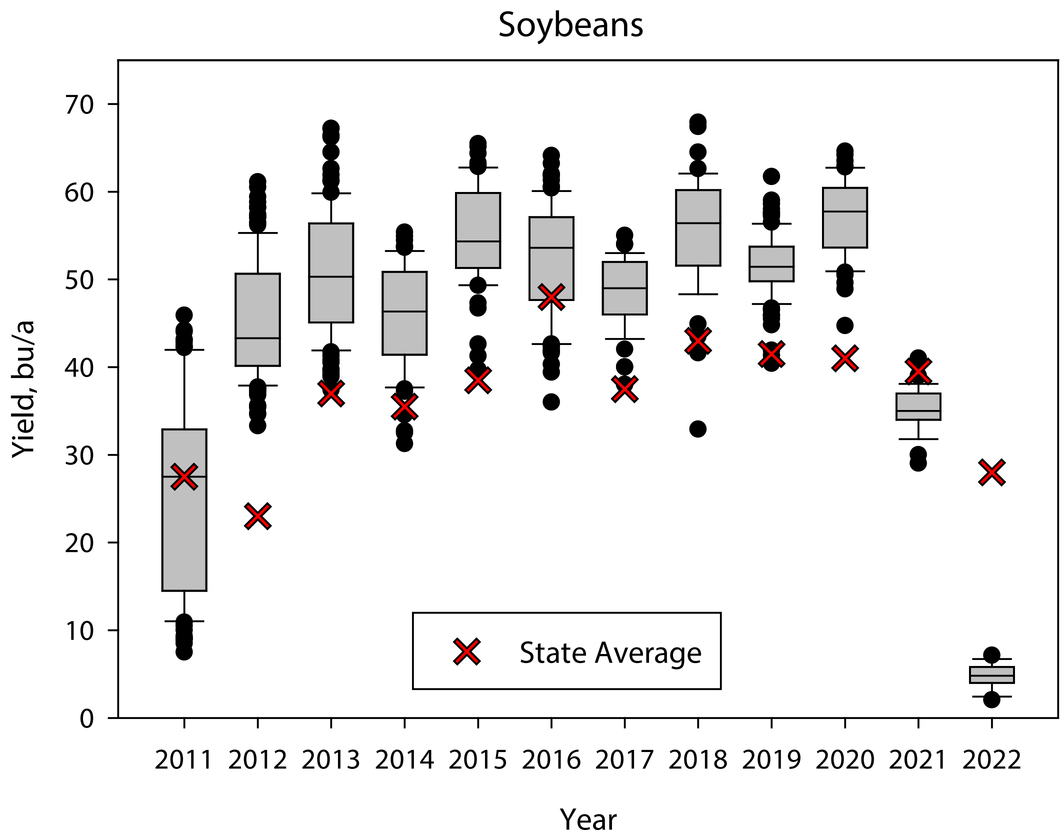

Figure 3. Soybean yields from variety trials in southeast Kansas from 2008 through 2022. For comparison, average reported state yields for hard red winter wheat from Kansas are highlighted as a red X.