Role of Soil Nutrient Status in Microbial Activity and Disease

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Summary

The soil supports many living organisms, in addition to plants. Bacteria and fungi are critical components of the soil ecosystem, and play fundamental roles in the biochemistry of the soil. This study explores the interdependency of the soil microbiome and soil nutrient status.

Introduction

Soil microbes play a critical role in nutrient cycling in the soil. Microbes break down materials, including plant roots and biomass. The breakdown products of this digestion then become available to support the growth of plants. There is a strong symbiotic interaction between plants and microbes in the nutrient cycling of the soil. Plants release carbohydrates that are then taken up by microbes and used for growth and development. In exchange, the plant microbes deliver nutrients and water to plants, including N, P, and K, as well as micronutrients. This symbiosis is at the heart of nutrient cycling in the soil, and essential for optimal plant growth and productivity. The soil microbiome is very responsive to plants, changing even for different varieties of the same crop.

Some soil microbes can also be harmful, such as 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*)). Diseases reduce the yield and quality of soybeans and other crops in Kansas and throughout the world. Soil-borne diseases are prevalent in crop production fields. Control methods of disease include use of solarization to heat the soil, or chemical fumigation. Some plants have been shown to produce chemicals that act as biofumigants that control or reduce harmful soil microorganisms. These plants can be used to create suppressive soils that inhibit the growth of naturally-occurring soil-borne diseases. Alternative management practices, such as addition of animal manures, have also been used to alter the soil microbiome to improve control of disease organisms. Use of cover crops, such as the high-glucosinolate mustard (*Brassica juncea*) can reduce fungal populations that caused charcoal rot in both soil and soybean plants. Conversely, some management practices increase disease organisms, such as use of corn stover, which is a host of multiple disease organisms, or tillage.

This research tests the hypothesis that improving the overall soil health by supporting healthy soil microbial communities can reduce disease pressure. We are exploring how to create

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suppressive soils by altering management practices to reduce disease pressure. The research reported here explores the relationship between soil microbial activity and soil nutrients. 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 in the spring, 2024. Plots included: fallow, mustard cover crop, soybean, corn stubble, cow manure, and plastic sheets. Plastic sheets provide a "solarization" treatment, increasing soil temperature and potentially reducing soil microbes. Plastic sheets were placed on plots and held in place with concrete blocks. Corn stubble was spread to about a 2-in. layer. Corn stubble may increase the soil microbial activity by providing more carbon, but is also a host for *M. phaseolina*, potentially increasing the disease prevalence. Cattle manure was spread to about a 2-in. layer on the plots. Cattle manure adds additional microbes to the soil, increasing the soil microbial diversity and increasing food sources for microbes. The high-glucosinolate mustard, Mighty Mustard Pacific Gold (Johnny's Selected Seeds, Winslow, ME) was broadcast in plots in early April. The use of a 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*. Because of poor plant stand in the mustard, seeds were spread at additional times during the growing season. The fallow treatment was left unplanted and served as a control. Five cultivars of soybeans, ranging from MG 3.4 to 4.8, were also planted to test for variation in charcoal rot sensitivity.

Soil samples to a depth of 6 in. were collected at three time periods, in spring prior to implemented treatments, mid-season, and after harvest. Soils were analyzed for nutrients at the K-State Soil testing lab in Manhattan. Soil microbial activity was measured with the 24-hour CO_2-burst test (Solvita, Woods End, ME). Disease prevalence was tested at the Plant Pathology lab in Manhattan.

Results and Discussion

Differences in microbial activity were observed based on management as determined by soil respiration measured with the Solvita CO_2 Burst test (Figure 1). Soybean plots varied from a low of 73.5 to a high of 86.8 ppm, indicative of a medium range in soil microbial activity (Solvita, 2017). The plots with added corn stubble and mustard seed were similar, at 78 and 67 ppm, respectively. The plots with manure were much higher, at 100 ppm. Conversely, the fallow and solarization plots were the lowest, at 52 and 48 ppm, respectively. The corn stubble and manure had much higher microbial activity (note different scale of axis) at 290 and 180 ppm, respectively. This level of activity would be rated high for microbial activity (Solvita, 2017).

Soil microbial activity increased as major and minor soil nutrient levels of increased (Figure 2). This pattern was observed for pH and minor nutrients as well, including sulfur, boron, and calcium (data not shown). Much greater rates of increase in soil microbial activity were observed as soil carbon increased (Figure 3). This was apparent for both total organic carbon and organic matter. Increased soil microbial activity been observed in other studies, and is indicative of the importance of carbon as a food source for microbial growth and production. The only soil nutrient that had a negative impact on soil microbial activity was NH_4.

Conclusions

Soil nutrients are essential for plant growth and development. They are also critical for the soil microbes. The role of soil microbes in plant nutrition is important to maintain the nutrient cycle within the soil. A healthy soil microbial community supports crop production. Here, we demonstrate differences in soil microbial activity with management, and the increase in soil microbial activity with increasing soil nutrient levels.

Acknowledgements
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References

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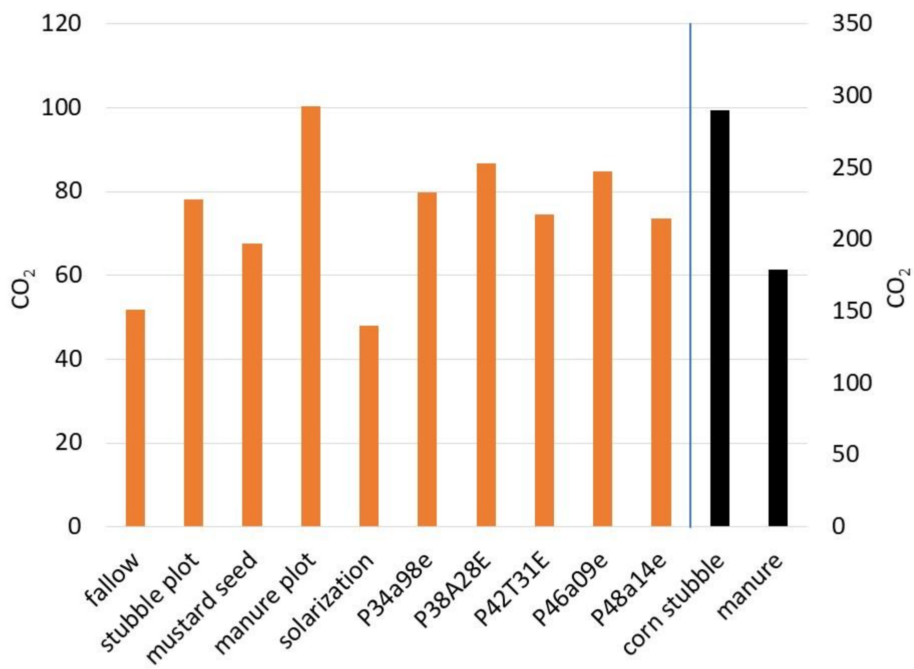

Figure 1. Difference in soil microbial activity as measured by the Solvita Burst Test under different management conditions at mid-season. Activity in soils from 5 different soybean cultivars, and plots with added corn stubble, manure, solarization, mustard seed are in orange, on the left axis. Microbial activity for only corn stubble and manure are in black, with the right-hand axis.

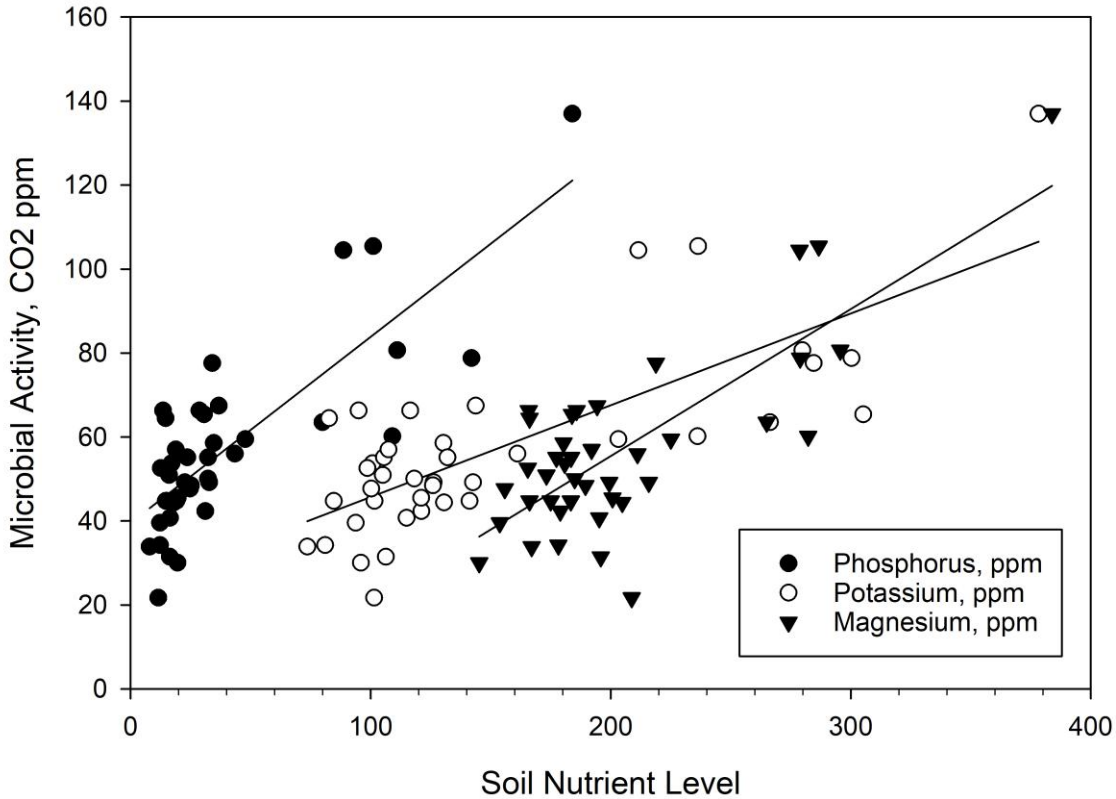

Figure 2. Change in soil microbial activity, measured as soil respiration in CO_2 ppm as soil nutrient level changes for phosphorus ppm (solid circles), potassium ppm (open circles) and magnesium ppm (closed triangles).

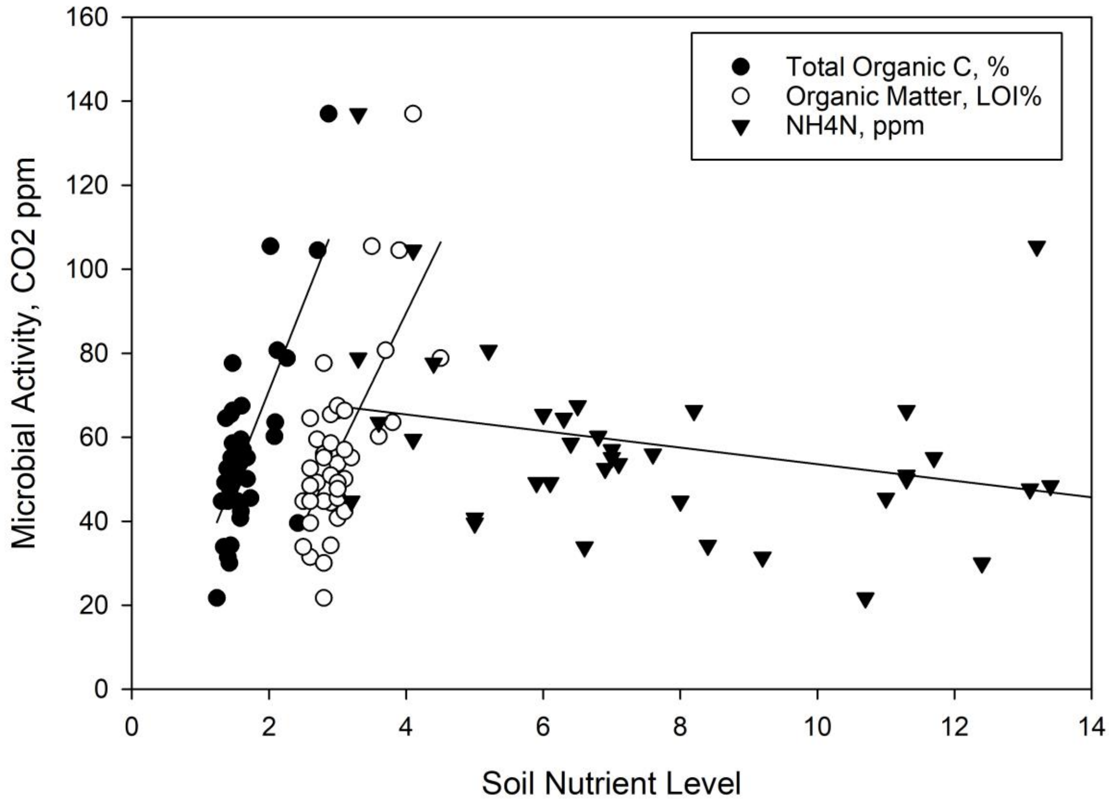

Figure 3. Change in soil microbial activity, measured as soil respiration in CO_2 ppm as soil nutrient level changes for total organic carbon % (solid circles), organic matter loss on ignition % (open circles) and NH_4N ppm (closed triangles).