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Environmental impact and influence on urban tree health of biochar and biosolids

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Introduction

Biosolids (BS) and biochar (BC) are two soil amendments that have been used to remedy urban soils, which often have poor water and nutrient retention due to anthropogenic influence.[6] BS has been shown to greatly encourage tree health, but it has also contributed to nutrient leaching.[3] BC, in contrast to BS, may slightly contribute to tree health,[2,3,4] but also have considerable potential to promote a healthy environment.[2,3,4]

The goal of this research is to find a soil amendment, or combination of soil amendments, that will promote both tree and environmental health. When mixed in with several varieties of soil types and coverings, our hypothesis is that biochar will have a positive environmental impact+ and contribute slightly to tree health,++ while BS will greatly encourage tree health but have a less positive environmental impact. If BC and BS are combined in a one-to-one ratio, we hypothesize a more positive environmental impact than BS alone, and greater tree health than BC alone.

+"Environmental health" = more growth, larger and greener leaves, and fuller crowns
++"Tree health"= less nutrient leaching, higher water retention, and fewer CO2 emissions

Methods

The research was conducted during the second summer (2016) of a study commenced in 2015.[1] Seventy-two mesocosms of *Ulmus parvifolia* were studied in The Morton Arboretum's Research and Tree Breeding Nursery.

Soil Varieties

- Full factorial with 3 replications. See Table 1.

Treatment		Soil Type		Cover	
Name	Composition	Name	Composition	Name	Composition
Biochar (BC)	1 gal. BC 1 gal. sand	Forest	15 gal. unscreened topsoil	Turf	*Poa pratensis* 16 seeds/in²
Biosolids (BS)	1 gal. BS 1 gal. sand	Tree	4.5 gal. unscreened topsoil 4.5 gal. 3/8" screened topsoil 3.75 gal. sand 2.25 gal. compost	Mulch	2" woodchip covering
BC + BS	1 gal. BC 1 gal. BS	Urban	3.75 gal. screened topsoil 9.5 gal. sand 2.25 gal. compost		
Null	2 gal. sand				

Table 1. Soil varieties: treatment, soil type, and cover

Measuring a Healthy Environment

- Nutrient leaching: Collect leachate after each rain event, and analyze phosphate and nitrate concentrations using colorimetry
- Soil respiration: LI-COR Biosciences (2010) LI-8100A
- Volumetric Water Content (VWC): LI-8100A

Measuring a Healthy Tree

- Chlorophyll concentration: SPAD 502 Plus Chlorophyll Meter
- Leaf area: measure average leaf size using WinRHIZO software
- Relative Diameter Growth (RDG): diameter growth 2015-16
- Twig growth: average twig growth from 2016 growing season
- Crown Fullness: rate the crowns on a 1-5 scale

Results

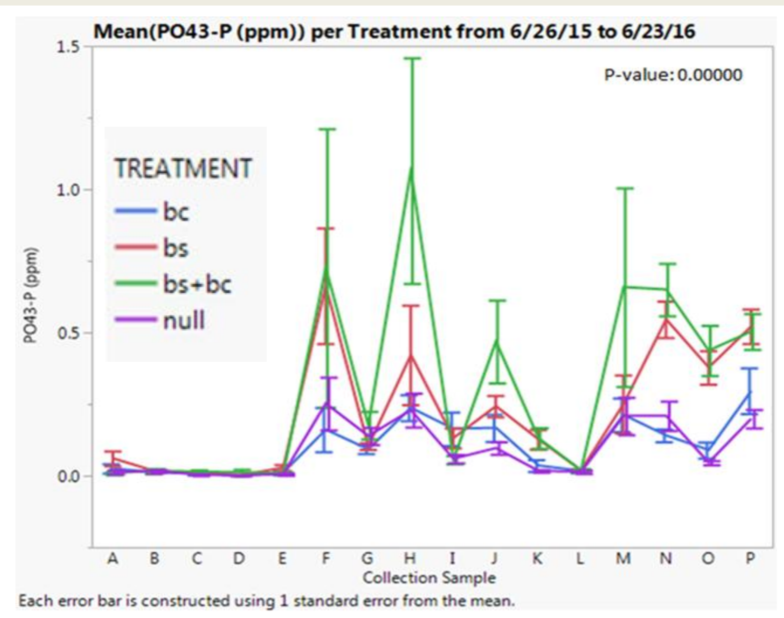

Figure 2. Phosphate trends from 2015-2016

Phosphate Leaching: No significant treatment effects appeared in 2015, but phosphate leaching was significantly greater with BS and BS+BC in 2016. BC neither increased nor suppressed phosphate leaching in either year. See Figure 2.

Nitrate Leaching: BS and BS+BC contributed to significantly higher nitrate leaching in 2015 and did not increase leaching in 2016. BC neither increased nor suppressed nitrate leaching either year. See Figure 3.

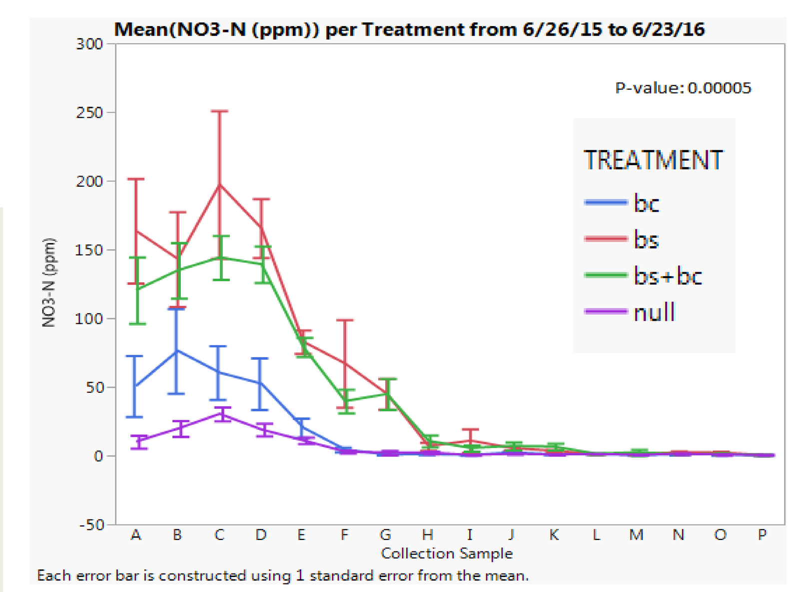

Figure 3. Nitrate trends from 2015-2016

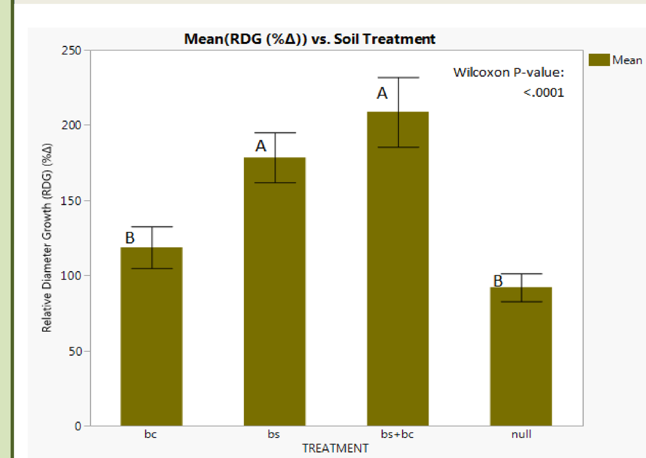

Figure 4. Treatment effects on RDG

Relative Diameter Growth: BS and BS+BC contributed to a significantly greater diameter growth than BC and null. No difference appeared between BC and null. See Figure 4.

Chlorophyll: Treatment had the greatest effect on chlorophyll content both years, with BS and BS+BC contributing to higher chlorophyll levels. No difference appeared between BC and null. See Figure 5.

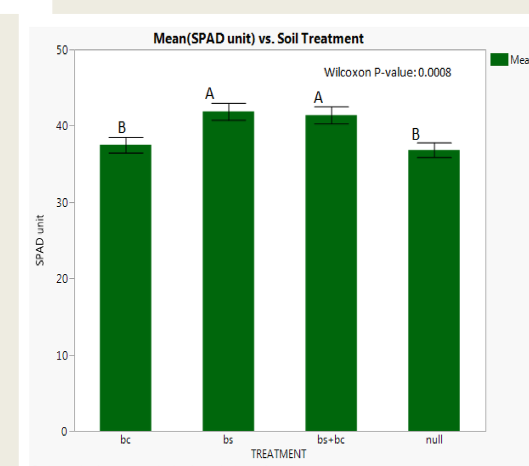

Figure 5. Treatment effects on chlorophyll

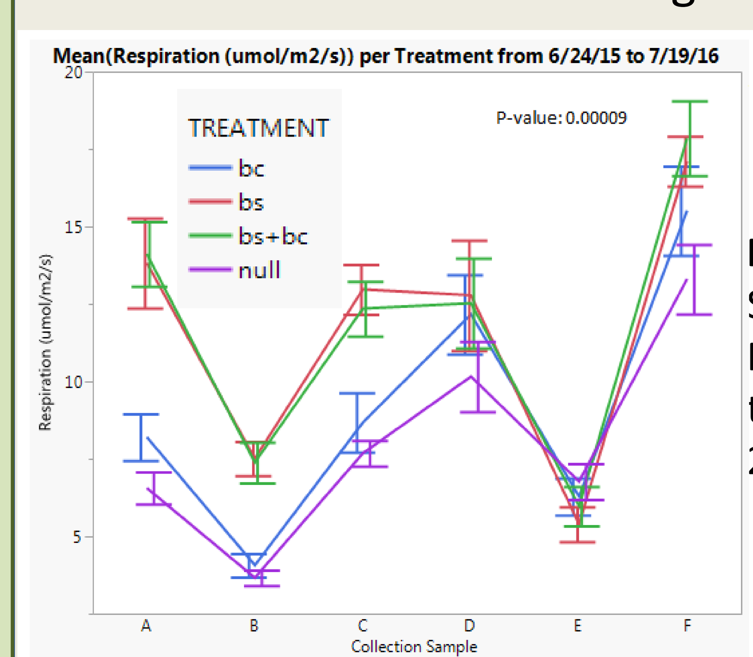

Figure 6. Soil Respiration trends from 2015-2016

Soil Respiration: In 2015, BS and BS+BC contributed to significantly higher CO2 fluxes, and BC neither increased nor suppressed CO2 fluxes. In 2016, treatment had no significant effect on soil respiration. See Figure 6.

Volumetric Water Content, Twig Growth, Leaf Area, and Crown Rating: none showed treatment effects.

Figure 1. Seventy-two mesocosms arranged in The Morton Arboretum nursery

Conclusion

- BS had a more negative environmental impact than BC and null, while contributing positively toward tree health in some ways. This was in general agreement with our hypothesis.
- BC neither contributed to nor suppressed any negative environmental impact, and it did not contribute to tree health, in contrast with our hypothesis.
- Many factors influence the function of biochar as a soil amendment, including the biochar feedstock, pyrolysis procedure, postproduction handling, and application rate.[5]
- Although this biochar did not appear to influence environmental health or juvenile tree health, future studies should continue to explore the many variables that impact the function of biochars.

Acknowledgements

We would like to thank The Morton Arboretum and the Center for Tree Science for funding this research. Special thanks to Christine Carrier, Undergraduate Research Fellowship coordinator; Michelle Catania, Megan Midgley, Marvin Lo, and Jessica Turner-Skoff for their advice and assistance; and Maureen Livingston, Bill Prescott, Craig Mendel, and all MASS volunteers for their willing assistance in this project.

References

1. Cerminar, Jacob. (2016). Can Biochar and Biosolids improve urban soils for trees while preserving environmental integrity? Poster presentation at University of Wisconsin - Stevens Point College of Natural Resources Undergraduate Research Symposium
2. Lehamnn, J., Gaunt, J., and Rondon, M. Bio-char sequestration in terrestrial ecosystems—a review. (2006). *Mitigat. Adaptat. Strateg. Global Change 11*, 403–427.
3. Scharenbroch, Bryant C., Elsa N. Meza, Michelle Catania, and Kelby Fite. 2013. Biochar and biosolids increase tree growth and improve soil quality for urban landscapes. *Journal of Environmental Quality, 42,* 1372-1385.
4. Sohi, S. P., E. Krull, E. Lopez-Capel, and R. Bol. (2010). A review of biochar and its use and function in soil. *Advances in Agronomy, vol. 105,* 47-82.
5. Spokas, K.A., K.B. Cantrell, J.M. Novak, D.W. Archer, J.A. Ippolito, and H.P Collins. (2012). Biochar: A synthesis of its agronomic impact beyond carbon sequestration. *Journal of Environmental Quality, 41,* 973-989.
6. White, R.E. (1987). *Introduction to the Principles and Practice of Soil Science*. New York: Halsted Press.