

Biochar in Agricultural Systems

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Introduction

There has been a great deal of interest in biochar recently for many reasons, including bioenergy production, carbon sequestration, use as a soil amendment to improve productivity, and as an end use for animal manure. This publication serves as a brief introduction to biochar and many of the issues surrounding its generation and use. As a relatively new topic, it is developing rapidly. Hopefully, many of the unknowns discussed will be resolved soon.

What Is Biochar and How Is It Produced?

Most people are familiar with charcoal, which is produced by combusting wood in an oxygen-depleted environment and then used as a heating fuel. Biochar is produced in a similar fashion, but the term “biochar” is used primarily when the end use is a soil amendment. As with charcoal, biochar is a black product with a high carbon content. Biochar can be produced by a number of techniques, such as fast or slow pyrolysis and gasification. Fast pyrolysis produces bio-oil that can be used for energy, but this lowers biochar yield. Slow pyrolysis and gasification do not produce bio-oil but produce a higher yield of biochar. However, biochar yields do not typically exceed 40 percent by weight of the feedstock; therefore, a large fraction of the biomass is lost.

Variations in the temperature of biochar production also have a huge impact on the properties and quantity of the biochar produced. Biochar can be produced from a wide variety of lignocellulosic materials, such as wood, crop residue, and manure. Because it is a combustion process, the material must be reasonably

dry. For example, poultry litter with a moisture content of about 25 to 30 percent can be pyrolyzed, but dairy manure that has a moisture content of around 95 percent must have the solids separated from the liquids before combustion is possible.

Biochar is not the same as activated carbon, which is a compound used for purifying liquids and gases due to its high absorption capacity. Biochar would need to go through an activation step, which is too expensive for land application purposes. Because of the widely varying feedstocks and processing practices utilized, it is important to understand that all biochar will not be alike.

Why Consider Amending Soils With Biochar?

Many native soils in the Amazon basin are infertile, but “terra preta” soils were discovered that had been enriched with carbon before the arrival of Europeans. These soils have enhanced fertility, nutrient-use efficiency, cation-exchange capacity, water-holding capacity, and crop yields relative to the native soils. Exactly how these terra preta soils were amended is unknown. However, it is thought that charcoal products were used, which is why there is interest in amending soils with biochar to increase soil quality and productivity.

The fact that these terra preta soils are still enriched in carbon hundreds of years after they were amended has also generated interest in biochar applications to soils for carbon sequestration. The carbon in biochar has a different structure to that in soil organic matter because it is primarily made up of aromatic rings that are more stable and long-lasting. If carbon can be taken from

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the atmosphere by crops and turned into biochar that is a stable soil amendment, then there is a huge potential to sequester carbon in soils while also benefiting soil productivity.

Will Biochar Always Increase Soil Productivity?

Most studies show that biochar can increase soil productivity, but some do show decreased productivity. This is almost certainly due to the wide variety of biochars that can be produced and the variability between soils. Biochar can increase soil productivity through either the application of the nutrients and lime it contains or through improving soil properties. Minerals present in the feedstock are concentrated in the biochars produced, but much of the nitrogen and sulfur is lost during pyrolysis. Therefore, supplemental nitrogen will generally be needed when using biochars as a nutrient source.

The primary benefits of biochar to soil quality are thought to be through increasing the active surface area that can retain nutrients and increasing the water-holding capacity. We need a better understanding of these variables before widely recommending biochar applications to soils. For example, freshly produced biochars are hydrophobic and have low surface charge, but with time after land application, the surface of biochars can become oxidized — and thus, more reactive. Therefore, the full benefits of applying biochar to soil may not be realized for years. There are many ongoing studies on biochar production techniques and how the biochars produced will affect soil properties and productivity. Hopefully, we will have recommendations for biochar applications in the near future.

Feedstock Material for Biochar Production

A wide variety of feedstocks can be used depending on location, cost, and availability. The use of manure as a feedstock is particularly attractive in areas such as the Chesapeake Bay watershed that are under significant environmental pressure to curtail surface application of manure. Regulations in many areas limit the rate of manure that can be land-applied, so pyrolyzing manure into biochar and bio-oil could be beneficial. However, these regulations normally limit the land application of phosphorus and the phosphorus in the manure is retained in the biochar.

The phosphorus in biochar is of lower availability and higher concentration than it was in the manure, but the release rate into the soil is much lower than that from manure; therefore, it has the potential of being land-applied with lower nutrient runoff problems. The biochar is also much lighter than the manure it was produced from, and if it is then seen as a value-added product, it will make long-distance transport and use out of areas of animal production more feasible.

Biochar Application Rates

Biochar is not like fertilizer, which generally needs to be applied annually. As biochar is stable in soils, it could be built up to an optimum level which will then remain constant indefinitely. Currently, we do not know what these optimum rates are, but some studies have reported adding biochar up to 20 percent of the soil by volume. Biochars from manure may have high salt contents — which would limit annual application rates — but as these salts are leached, more biochar could be applied.

Conclusion

Biochar production holds great promise for bioenergy, a value-added manure product, and a soil conditioner. However, as there are so many variables in feedstock and biochar production, many details remain to be refined. As this new and exciting technology advances, the role of biochar in agricultural systems will probably increase.

For further information:

Lehmann, J., and S. Joseph, eds. 2009. *Biochar for environmental management: Science and technology*. Sterling, Va.: Earthscan.