Biological Charcoal is a valuable resource for Agriculture

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Biological charcoal (called biochar) is the product of incomplete combustion of natural organic materials. The wide variety of organic chemical components in the original natural organic material are transformed into new compounds. Many of these new compounds will consist of charcoal (elemental carbon) or some intermediate form of carbonized organic compounds.

What is the value of biological charcoal? Thousands of raised platforms along the Amazon River in Brazil discovered the *terra preta* “black land” by explorer Herbert Smith in 1879 (Marris, 2006). This soil is one to two feet thick and consists of soil intermixed with charcoal. *Terra preta* contains a much higher level of plant available nutrients (especially carbon, nitrogen and phosphorus) than does the surrounding soils.

These *terra preta* soils were rediscovered by the Dutch researcher Wim Sombroek in the mid 1950s while doing studies in the Amazon. He described these soils in his book *Amazon Soils* (1966) as being similar to “plaggen soils” (a scientific term meaning human modified soils improved by adding lime, manure, or other amendments including charcoal and ashes).

Wim Sombroek published an article in 1992 suggesting these *terra preta* soils could solve part of the world’s problems associated with global warming. Sombroek argued the conversion of biological material into charcoal would be very beneficial. The plant material normally will be decomposed by soil microorganisms within a few years and will return the plant carbon to the atmosphere as carbon dioxide (CO_2) as a part of the normal ecosystem services soil provides to the environment. Sombroek realized if instead of allowing this carbon to escape from the soil as carbon dioxide, the conversion of the plant material into charcoal would provide several distinct benefits.

As indicated, the lumps of charcoal will serve as a protective haven for billions of beneficial soil microorganisms. In addition, the plant roots may grow adjacent to and possibly into these lumps of biochar allowing these roots to obtain nutrients within the lumps of biological charcoal. From the point of view of the environment, the biochar charcoal will remain in the soil indefinitely. Only when the soil physically is burned (as happens with charcoal in a Bar B Que) does this carbon return to the atmosphere as carbon dioxide. Consequently, the charcoal has sequestered the carbon in the soil in a form whereby global warming is reduced by the amount of charcoal carbon sequestered in these *terra preta* soils. In addition, the charcoal acts as a sponge holding water for plant growth and slowly allowing the roots to absorb this water during several days between rainfalls or irrigation cycles.

Researchers (Johannes Lehmann at Cornell University in Ithaca, New York and Bruno Glaser at the University of Bayreuth in Germany) have tried to duplicate the formation of these *terra preta* soils by creating biological charcoal (biochar) through various processes of heating plant debris in the absence of oxygen gas (O_2).

Biochar is much more environmentally friendly. Crops can grow much better when the roots are in contact with biochar. The carbon is sequestered in the soil indefinitely. Normally, the soil humus (organic material) persists in soil for several thousand years. Biochar will remain in the soil until the soil is burned. Even a normal slash and burn process or forest fire will burn only the top inch or two of soil. Biochar exists in the soil to what ever depth the people incorporated it. Thus, even it a fire occurs, most of the biochar will escape being burned and will persist for centuries in the soil.

Almost any form of natural organic material can be converted into biochar. Thus, material considered previously to be organic waste can be transformed into biochar to create new *terra preta* soils in the United States with the possibility of obtaining carbon credits for enhancing the quality of the environment. Johannes Lehmann (2007) estimated about 10 per cent of the U.S. fossil fuel emissions could be diverted into biochar thereby providing additional carbon credits.

The lumps of biochar will serve as major beneficial regions for the growth of endo-mycorrhizal fungi. These fungi live inside plant root cells and their fungal hyphal mycelium (cob web growth) extends into the soil similar to root hairs, thereby absorbing soil nutrients and bringing these nutrients to the plant root enhancing overall growth.

The agricultural benefits of biochar can be enhanced even more by combining biochar with vermiculture. Vermiculture is the process of using earthworms to digest fresh plant material and enhance nutrient availability. The vermiculture process will return carbon dioxide to the atmosphere, but the biochar will not.

The earthworms defecate fecal pellets called earthworm castings. These castings are very rich in humus and nutrients. As an example a study in Connecticut (Lunt and Jacobson, 1944) reported earthworm casts increase the nutrient availability of the soil by 1.4 fold for calcium (Ca), 3.0 fold for magnesium (Mg), 11.2 fold for potassium (K), 7.4 fold for phosphorus, and 4.7 fold for nitrate-nitrogen (NO_3^--N).

In addition, the passage of the soil and plant debris through the earthworm gut results in the production of an abundance of beneficial carbohydrates as gums, slimes and mucilages. These sticky materials bind the sand, silt and clay particles together along with the humus into the earthworm castings. These aggregates promote air and water movement and enhance root penetration in soils (Russell, 1973).

No specific studies have been published on the combined use of biochar and earthworm composing. However, all of the benefits will result in improved soil quality, enhanced environmental quality and overall beneficial nutrient enrichment for plant growth and crop production. The net environmental benefit provides carbon credits and long term improvement of all soils.

References

Lee, K. E. 1985. Earthworms Their ecology and relationships with soils and land use. Academic Press, San Diego, CA.

Lehmann, Johannes. 2007. A handful of carbon. Locking carbon up in soil makes more sense than storing it in plants and trees that eventually decompose argues Johannes Lehmann. Can this idea work on a large scale? Nature 447:143-144. May 10, 2007.

Lunt, H. A. And H. G. M. Jacobson. 1944. Soil Science 58:367.

Marris, Emma. 2006. Black is the new green. Nature 442:624-626. August 10, 2006.

Russell, E. Walter. 1973. Soil conditions and plant growth. Longman Group Limited, London, United Kingdom.