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JOHN'S CORNER

Soil Amendments - Bio-Char

By John Ferguson

This week we are going to talk about another type of ash product that is showing real potential in gardening called Bio-Char (sometimes referred to as black carbon). The interest in Bio-Char started with the work of Wim Sombroek, PhD and his research on soils in South America that have stayed fertile for thousands of years that are named the "terra preta" soils or Amazonian Dark Earth.

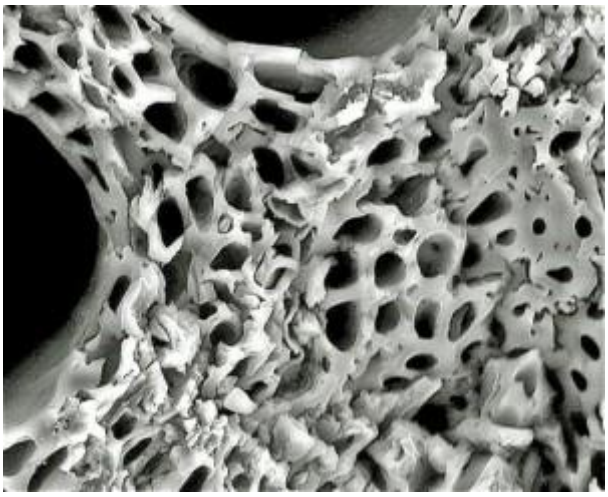
These patches of charcoal rich soils were created by native people living in the Amazon basin. Not only were these soils richer in nitrogen, phosphorous, zinc, magnesium and other nutrients as compared to typical tropical soils, they had up to 70 times the amount of carbon in the form of bio-char.

There is a lot of interest in bio-char as a means of sequestering carbon in the soil and to offset carbon dioxide rise in the atmosphere as well as reduce the effects of global warming. A study published in the Journal Mitigation and Adaptation Strategies for Global Change (2006) found that more carbon could be stored in the soil in the form of bio-char than is produced by the burning of fossil fuels each year. Additionally it would increase production in agriculture and horticulture and reduce chemical nutrient run-off that is polluting our rivers and lakes. Sombroek called these new soils amended with bio-char, "terra preta nova".

Bio-char is a charcoal like substance produced when organic matter is burned at a low temperature. There is a lot of research currently being done on bio-char but with two different goals. The first is to convert the bio-mass into synthetic fuels and biogas for energy production. These techniques use very high temperatures (over 500 degrees C) and very fast reaction times. Most of the biomass is converted into bio-fuels with little bio-char produced (around 10% of original biomass).

The second method is to produce bio-char for use in horticulture and agriculture. These techniques use lower temperatures (temperatures below 500 degrees C) and much longer reaction times and produce less syn-fuels and more char.

In both cases a special oven or kilns is used and the burning (pyrolysis) occurs with little or no oxygen present (30-40% of original biomass). The pyrolysis causes the carbon to in the biomass to re-form into aromatic carbon rings that are extremely resistant to decay with lots of pore space and surface area (picture below). The pore spaces make good homes for microbes to live in and for water molecules to stick to, which give the char its ability to absorb and hold water till plants need it. They also allow many plant nutrients to attach to the char and prevent them from leaching out of the soil.



Bio-char has a tremendous surface area with only 0.03 ounces (one gram) having a surface area of over 1,000 square yards!

After reading numerous textbooks and studying hundreds of research papers and articles, I have observed one pattern in horticultural and agricultural applications; slow low temperature bio-char seems to almost always give a positive result while fast high temperature bio-char gives neutral and even negative results. The properties and value of bio-char varies greatly and is influenced by the material from which it is produced and its manufacture. Fast high temperature bio-char tend to be alkaline while low temperature low bio-char tends to be pH neutral.

Over time the absorption and cation exchange capacities of bio-char increases and pH becomes more neutral. Bio-char can hold 6 times its weight in water and can greatly increase a sandy soil's ability to hold and store water. Application rates depends on the specific soil type and the plants it is applied to. Best results occur in sandy drought prone soils (it does aid aeration in clay soils and reduces cracking and swelling but may reduce water infiltration).

Several studies have shown that bio-char greatly increases the growth and colonization of soils by mycorrhizal fungi that are so critical for a plant's absorption of nutrients, growth and resistance to disease. Other microbes growth is also increased where they absorb carbon dioxide (CO_2) from the air converting it into biomass that eventually turns into humus.

Research has shown that bio-char enriched soils reduce carbon dioxide (CO_2) emissions by 60-80%. It also reduces nitrogen oxides emissions (NO_2) which contribute are 200X worse than CO_2 in its global warming effects. Note: One of the reasons artificial fertilizers have to be applied so often is that most of the nutrients leach out and pollute the air and our waterways.

Often applied with compost (source of beneficial microbes) and to reduce bio-char's dusty nature. It can be mixed into a slurry and applied topically or injected into the soil.

The archeological studies suggest the bio-char produced in the Amazon basin was a mix of bones and skin from animal, fish waste, fruits and vegetables scraps, branches and limbs, manure (both animal and human), hence was also a good nutrient source. For example bones are a good source of phosphorus (P) as well as calcium (Ca) and magnesium (Mg). Currently I am not aware of any bio-char sold commercially that uses these materials. As a result two different chars may look the same to the eye but have very different properties.

SUMMARY:

Bio-char is a very promising tool for gardeners to have a great beautiful garden. It does not replace a good compost, native mulch or organic fertilizer. However it is a very cost effective way to increase a soils fertility.

APPLICATION:

A good starting point is to apply one cubic foot of bio-char to 48 square feet of soil. Since it lasts a very long time, it is only applied one time (very cost effective).

Several studies suggest that bio-char works best if pre-treated first by soaking with water, composting it, or drenching with compost tea.

PROS:

- increases water retention
- increases nutrient retention (less leaching hence less fertilizer required)
- effects last a very long time

- reduces greenhouse gasses
- improves a soils physical properties
- improves a soils aggregation, porosity, tilth
- acts as a catalyst that enhances a plants ability to absorb nutrients and water
- habitat for beneficial microbes
- high cation exchange capacities (CEC)
- low in tars, resins and other compounds as compared to cooking charcoal
- easy to spread
- renewable resource
- carbon sink
- converts organic solid waste into a useful form
- bio-fuels may be a by-product
- reduces aluminum (Al) toxicity
- increases a soils microbial biomass
- increases biological fixation of nitrogen(N) from the air into the soil
- increases the humus content of soil
- increases some trees resistance to disease

CONS:

- quality, type, and value varies greatly
- tends to be very alkaline and may change the pH of the soil
- very dusty and dangerous to breath in powdered form
- rubs off on hands and clothes
- nutrient content is insignificant (most types currently available today)
- powdered forms blows in wind and can create a mess (avoid windy conditions)
- respiratory dust masks should be used when dry
- low quality biochar has tars and resins that inhibit plant growth
- limited availability

- price varies greatly
- very high temperature (1,000 degree C) has PAH (poly aromatic hydrocarbons) and dioxins which are human health toxins
- some bio-char has been shown to kill algae in waterways (this can be pro or con)

Resources:

Amazonian Dark Earths: Wim Sombroek's Vision, Multiple Editors, Springer, 2009, ISBN: 978-1-4020-9030-1

BIOCHAR: Environmental Management Science and Technology, J. Lehmann and S. Joseph, Earthscan, 2009, ISBN: 978-1-84407-658-1

The Biochar Solution- Carbon Farming and Climate Change, Albert Bates, New Society Publishers, 2010, ISBN: 978-0-86571-677-3

The Biochar Debate, James Bruges, Chelsea Publishing, 2009, ISBN: 978-1-60358-255-1

Journal of Environmental Quality, July-August 2012, Volume 41, #4 entire issue was devoted to research papers on Bio-char.

The International Biochar Initiative (IBI)

www.biochar-international.org

Note 1: If anyone wishes to try Bio-char, both Buchanan's Native Plants (611 E. 11th St., Houston) and Nature's Way Resources (101 Sherbrook Circle, Conroe/Woodlands) have brought in a few bags for gardeners to try and give us your feedback. This is a single species bio-char produced from dead pine trees killed by pine beetle infestations.

Note 2: Bartlett Tree company has been doing a lot of research on bio-chars and trees. Their organic division is currently using the same bio-char above in the Houston area. The regional manager is Gene Basher and The Woodlands/Conroe representative is Joseph Keefe and they can be reached at (713) 692-6371.

Note 3: Bio-char IS NOT cooking charcoal. Cooking charcoal is toxic to many plants due to the chemical treatment applied to make it burn better and more even.