Biochar, Agrichar, Terra Preta

Black Gold for Soil, Long-Term Carbon Storage for Earth

by Jean English, Maine Organic Farmers & Gardeners Assoc. Newsletter, Fall 2008

Biochar (agrichar) is a product of pyrolysis–burning plant material under controlled, low-oxygen conditions (in a kiln, for example) to produce charcoal. Adding this highly stable form of carbon to soils may increase plant yields (especially on degraded soils); reduce nutrient leaching; cut fertilizer needs, thus decreasing runoff of fertilizers and the energy needed to produce, transport and apply fertilizers; and significantly reduce greenhouse gases (CO2, methane and nitrous oxide). Northern gardeners may find that applying the material to the soil–on top of snow in spring, for example–darkens and thus warms soil sooner and enables them to plant earlier.

This material holds so much promise that biochar is the sole subject of an international conference in England this September; a International Biochar Initiative has begun; and an amendment to the 2008 Farm Bill, added by U.S. Sen. Ken Salazar (D-Colo.), approves grants "for research, extension, and integrated activities relating to the study of biochar production and use, including considerations of agronomic and economic impacts, synergies of co-production with bioenergy, and the value of soil enhancements and soil carbon sequestration."

How Does It Work?

As plants photosynthesize, they take CO_2 out of the atmosphere. When biochar is made, some C returns to the air when plant matter is burned (during pyrolysis), but calculations suggest that 20 to 50% of the C in dry plant material can remain in biochar and, when added to soil, can remain there for hundreds or thousands of years (far longer than most of the carbon in compost or plant or animal residues added to soils, which oxidize and return C to the atmosphere fairly quickly), so biochar production is "net carbon negative."

Soil scientists talk about the "living," the "dead" and the "very dead" categories of organic matter (OM). Biochar is very dead – i.e., highly broken down and very resistant to change. This is why it lasts so long in soils. It will not replace the living OM faction (fungi, bacteria, plant roots, earthworms, etc., that decompose plant and animal matter and "work" the soil) or the dead OM faction (fresh crop residues, recently added manures) but can supplement them, increasing the very dead OM faction (small size, well decomposed organic matter) in soils quickly.

According to soil biochemist Johannes Lehmann, "The benefits of biochar rest on two pillars:

1-extremely high affinity of nutrients to biochar (adsorption)
2-extremely high persistence of biochar (stability)."

Lehmann adds that "beneficial effects of biochar on both soil microbial functions and soil water availability are highly likely but not yet sufficiently quantified to be effectively managed."

Research resulting from the Farm Bill should help quantify these and other properties of biochar, including, for example, the optimum temperature and oxygen concentration for smoldering biomass of various compositions; the extent to which biochar production can mitigate greenhouse gases; and rates of biochar applications to various soils.

Regarding greenhouse gases, using N fertilizers, for example, puts nitrous oxide into the atmosphere; but research in Colombia showed that adding biochar to soils reduced the problem by 80% while also eliminating methane emissions from the soils. Methane is a far worse greenhouse gas than carbon dioxide.

Rebecca Renner cites U.K. eco-entrepreneur Mike Mason's claim that by applying biochar, theoretically, "arable lands could hold carbon equivalent to all the carbon in the 200 million tons of anthropogenic CO_2 in the atmosphere today."

Regarding yields, researchers in New South Wales applied about 4.5 U.S. tons/acre (about 20 lbs./100 sq. ft.) to carbon-depleted soils and doubled the biomass of soybeans and tripled the biomass of wheat.

Long History of Use

Even without exact data, biochar has been used for thousands of years. The rich, highly fertile, dark soils of the Amazon's "terra preta de indio" – probably the result of slash and smolder practices of local farmers for eons – produce high crop yields even under intense cultivation in an area where soils are otherwise poor. The Japanese have long amended soils with charcoal, and recent research there and elsewhere shows increased yields, possibly due to a combination of increased soil pH; increased nitrogen, phosphorus, calcium, fungal, and microbial content; decreased aluminum availability; increased cation exchange capacity and water-holding capacity; and better root development.

Making biochar also produces energy: As hydrocarbon chains in plant material are broken down, gases—hydrogen gas, methane and others – are produced and can be burned. Professor Tom Jeffries of the University of Wisconsin says that over a million vehicles were powered by wood gasifiers in Europe during WWII when oil was not commonly available (see "Chicken John's" video in the resources for a modern truck fueled by a gasifier); and a company called BIOTECH has installed thousands of biogas plants in Kerala, India, that burn food waste and human waste to make gas for cooking and some electricity for lighting, with the residue being used for fertilizer.

Julie Major, writing of a biochar demonstration held in Honduras by Sustainable Harvest International staff, says biochar can be made simply by piling any organic material, setting it on fire and covering it with soil to exclude air.

Resources

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