Charcoal, Agriculture and Climate Change

by Richard Haard, Ph. D

Here is a global issue – our atmospheric carbon cloud. This emerging method for mitigating carbon emissions by burying charcoal needs advocates in order bring sequestration into play along with reductions of carbon emissions. It will take work on all fronts to reduce the carbon in our atmosphere including this rediscovery of Amerindian agriculture – Terra Preta

Let us first consider the difficulty of conducting farming in the humid tropics of Asia, Africa and South America. In this environment it is very difficult to maintain productive fertility of a farming tract for any length of time because of rapid decomposition rates of organic matter. These Oxisols (a soil classification) are naturally low in calcium and potassium while phosphorus is tied up in a complex with Aluminum mostly unavailable to plants.

Without continuously adding manure, compost or chemical supplements this soil type becomes non-productive in 2-3 years and must be turned back to revert to forest for 10 to 20 years before farming can be supported again. Even with this nutritional support 10 years would be a maximum cropping cycle before an extended fallow period.

After recovery of the land the farmer then slashes and burns the accumulated vegetation and repeats this cycle. Hence the term Slash and Burn (Swidden) agriculture. Now prominent scientists are advocating a replacement with a new kind of agriculture - Slash and Char. A growing system that also has advantages in the temperate zone.

Figure 1. We see this agricultural practice underway in the Amazon River headwaters. In the upper portion bulldozers have chained the forest down in preparation for burning and lower center we see dark bands of potassium enriched soil from the ash deposited by the fires. Photo credit: Nickolaus Foldi, Santa Cruz, Bolivia

Slash and Char

Slash and Burn agriculture is practiced by 300 to 500 million people on one third of the 1500 million hectares of arable land on the planet. Yet pressures remain high for clearing of natural habitat in order to expand agriculture. This is because of the expanding population, countries need for export market income and American and EU demand for biomass fuels. In Brazil alone carbon emissions from annual forest clearing amounts to 20% of the total released in the country.

There is another type of tropical agriculture called slash and char which would promote soil fertility, allow for shorter rotation periods and also reduce dependence on chemical fertilizers. This farming technique was formerly practiced by the Amerindian people 500 to 2500 years ago was discovered independently in Asia. It is quite a simple concept actually, as these native Amazon Rainforest farmers had only stone tools and felling the forest for fresh, fertile ground was very difficult. Instead, they conducted a smothered combustion of agricultural debris, and supplemented this with domestic manure and household debris. This charcoal built up in the soil over time and became a durable substitute for soil organic matter. This black carbon lasts for ten's of thousands of years in the soil as opposed to a few seasons at best. The result is a soil with chemical and biological properties that convert unproductive tropical oxisols to fertile soils that are still farmed even 1000 years after the original people have disappeared.

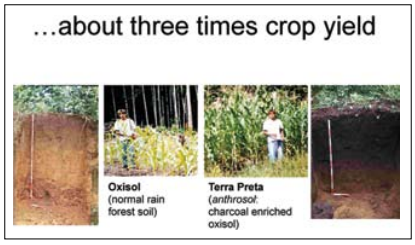

Figure 2. Cutaway view of tropical soils showing on left the normal rain forest soil where nutrients are transient and the Terra Preta de Indio soils with black carbon that is now attributed to human activities of transport of food, waste, and fuel at prehistoric dwelling places. Image credit Julie Major, plate taken from PowerPoint presentation by Folke Gunther cited in additional readings below

Here then we have a way to take pressure from land clearing in the tropics, to make more food for people and most interesting of all, bury charcoal to mitigate for atmospheric carbon pollution. Large scale adoption of slash and char, conversion of agricultural and forest waste to biochar and biofuel production with charcoal as an end product could cumulatively result in carbon sequestration greater than current emissions from fossil fuels. Indeed this system of burying charcoal is superior to tree plantations and standing crop biomass because the latter system is transient and once a climax succession stage is achieved these forests can become carbon emitters.

Our progress at Fourth Corner Nurseries

Readers of this column may recall my earlier writing about our studies at the nursery with charcoal as a soil additive. Since 2003 we have been testing this material and a progress report on this research project is now posted at our website. We are encouraged by our early results from our block treatment study, a project that will continue for several more years. From our local fieldwork and also from reports of other hands on workers around the globe charcoal is an excellent material to use as a soil additive.

Burying charcoal improves the water holding capacity, soil pH, cation exchange capacity, base exchange and most important of all makes new habitat for beneficial microorganisms. The increase in surface area made available by charcoal is amazing. A single gram of charcoal powder can have a surface area of 1500 square meters. Far from being inert charcoal is a highly valuable component, providing active retention of nutrients as well as increased micro-life and stabilization of the chemical environment.

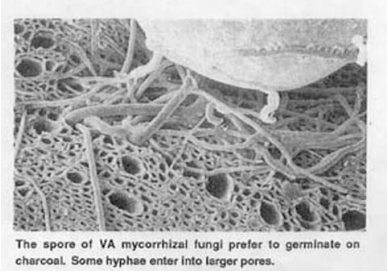

Figure 3. An example of fungus utilization of former wood structure in charcoal. Other images will show bacteria building up in the smaller spaces as well as the buildup of microbe populations over time. The inert nature of the charcoal helps to enrich the soil with chemoautotrophic bacteria and mycorrhizal fungi by limiting competition with sugar loving critters. Photo credit: Makoto Ogawa, Kansai Environmental Institute

Figure 4. Here is the result of charcoal pretreatment. These charcoal pieces were left large for ease of observation and composted with urine, wood chips, cooking drippings other food waste. After several months the initially hydrophobic charcoal became water saturated and home for fungi and many macroscopic invertebrates. Several more months in soil with Swiss chard revealed plant roots actively growing into charcoal pore spaces. Photo credit: Richard Haard, pretreatment research by Larry Williams

Hands on – How to make and use agricultural charcoal

Do not put fresh charcoal into the soil!

If you put fresh charcoal into soil the fertility might actually decrease. In addition, we have noticed charcoal has a hydrophobic property that needs to be biodegraded before water borne nutrients can be transmitted into the internal structure of what was once the vascular system of the plant. In the conditioning process, the large inner surface of charcoal causes nutrients to adhere making them temporarily unavailable until the charcoal is saturated. Once saturated the charcoal becomes attractive to plant roots and soil microbes. Because of the inorganic nature of this substrate the charcoal will serve as an enrichment culture for nitrogen fixing and mycorrhizial partners.

How to do it –

Think about composting with manure, urine, wood chips and /or nitrogen fixed by legume crops before or after use. We have been working on this approach as have others. Our local group has found that several months in these conditions, kept in aerobic conditions the charcoal is water saturated and completely involved with fungi and macroscopic invertebrates. Our best results thus far are with charcoal treated in this way.

If you are thinking about making agricultural charcoal you should know there is additional components of this conversion that benefits plants, this is smoke (pyroligneous acid) and burned soil. See Christoph Steiner's dissertation, pages 35 to 42. This is the chapter on current indigenous gardening methods. Terra Queimada - burned soil and Terra Cheirosa - smelling soil (pyroligneous acid) as well as the volatile materials that accompany fresh charcoal stimulate microbial activity. TPp or Terra Preta (prehistoric) is in anthropogenic deposits dated 500 to 2500 years old and has a different respiration response profile than the newly created TPn or Terra Preta Nova. You cannot expect to make TP overnight. It will always be a work in progress.

If you are a municipality think about pyrolysis rather than composting of shredded tree/garden waste or household debris and sewage/dairy solids. This is environmentally possible on a mini or meso scale and will pay for itself.

If you are a farmer you could char your waste rather than burn. In addition, woody cover crops like willows and alder can be a feedstock for a small pyrolyser, which can supply process heat, and charcoal for your field. Our pit char system, shown below, burned quite clean, yielded a high grade of low temperature charcoal that was a lot of fun to do at least once.

Great Expectations? Sometimes yes – great results. Where soils are poor and prone to nutrient leakage, (like tropical soils), differences will be striking. If your organic matter, soil fertility are already high then results will be muted but overall there will be an improvement in plant growth, ease of fertility management, and overall health of the soils.

A new Agricultural practice. Mark this thought as we will be learning more about this system of agriculture as research hits the main stream. Forthcoming will be best practices for mainstream agriculture. Additional income to farmers for carbon credits. Patents and trade secrets? Hell no. This is an open source intergenerational gift from our original peoples of South America and we owe this debt to them to use this traditional knowledge to protect the earth.

Additional Readings:

Slash and Char as Mitigation for Climate Change
Lehmann J, Gaunt J, Rondon M, (2006) Bio-char Sequestration in terrestrial ecosystems – A Review. In Mitigation and Adaptation Strategies for Global Change 11, 403-427

Lehmann, Johannes, A handful of carbon, Nature 447, 143-144, 2007

Basic knowledge and science
Web access for Dr Lehmanns work: http://www.css.cornell.edu/faculty/lehmann/biochar/Biochar_home.htm

Christoph Steiner, (2006) Slash and Char as Alternative to Slash and Burn, Dissertation, University of Bayreuth, Germany, 185 pp, Cuvillier Verlag Gottingen

Lehmann, J., D.C., Kern, B. Glaser and W. I. Woods (eds), 2003: Amazonian Dark Earths: Origin, Properties, Management., Kluwer Academic Publishers. Netherlands

Ogawa M (1994) Symbiosis of people and nature in the tropics. Farming Japan 28(5):10–30

T. H. DeLuca; M. D. MacKenzie; M. J. Gundale; W. E. Holben, Wildfire-Produced Charcoal Directly Influences Nitrogen Cycling in Ponderosa Pine Forests, Soil Science Society of America Journal, Volume 70, Number 70, p.448-453 (2006)

Gunther, Folke – We have been given access to an excellent educational PowerPoint program - Carbon Dioxide, Deciding For Our Future, Holon Ecosystems Consultants, Lund, Sweden. You can find it at: www.terrapreta.bioenergy lists.org

Haard, Richard – Richard's Flickr collection of charcoal and agriculture images and latest report on charcoal research at: http://www.fourthcornernurseries.com

An excellent web resource and reading list –
http://terrapreta.bioenergylists.org/about

An upcoming International Conference, Newcastle, UK , September 8, 2008 –
http://www.biochar-international.org/ibi2008conference.html

Source Material for this article included:
Folke Günther,Holon Ecosystem Consultants, Lund, Sweden, Carbon sequestration for everybody: decrease atmospheric carbon dioxide, earn money and improve the soil, submitted to Energy and Environment, 3/27/2007. This article can be downloaded at: www.terrapreta.bioenergy lists.org

Figure 5. Our Brazil replica, top lit, bottom draft charcoal making kiln. Two cords of dry alder and maple covered with wet hay, cardboard and soil. On the third attempt it worked like a charm and gave us a 2-year supply of high quality charcoal for our research and great barbecues. See the reference below to the Flickr file for a step-by-step description. Photo credit: Richard Haard