

Terra Preta:

Soil Improvement and Carbon Sequestration

"...there could be seen very large cities that glistened in white [...] many roads that entered into the interior [...] and besides this, the land is as fertile [...] as our Spain"

Francisco de Orellana, 1542

Orellana's reports of the exploration of Amazônia were forgotten in later centuries, and the Amazon Basin was thought to be an uninhabited jungle. Recently this view has been challenged and remnants of complex and large societies have been found throughout the Basin. But how was it possible to feed large populations in a region with such poor soils as in the Amazon? The answer lies in the fertile soils known as Terra Preta, first described by Charles Hartt in 1874 and now intensively researched in the Lehmann lab, both at Cornell University. These soils were made by indigenous populations before the arrival of the Europeans and are rich in nutrients and humus, which persisted for millenia until today.



<http://www.smithsonianeducation.org/science/impacts/graphic/terra-preta-graphic.html>

Slash-and-burn is regarded as the traditional system of land-use in the humid tropics, and also in the Amazon Forest. But is this really the case? How could this be true before the arrival of the Europeans in the 1500's who only then introduced steel and steel axes to the Amazon? Could Amerindians have gone into the jungle and felled huge trees every two years in a shifting cultivation system with a stone ax? The obstacle of felling trees with stone axes would seem to be a strong incentive to develop a permanent cultivation system, such as through Terra Preta soil management. (see Denevan, 1996)



Terra preta research inspired the development of a revolutionary technology that can have tremendous impact on rural livelihoods as well as carbon sequestration. It builds on the application of stable organic matter in the form of bio-char (biomass-derived black carbon or charcoal) in conjunction with nutrient additions. This bio-char is very stable, provides and retains nutrients for millenia, as seen in Terra Preta.

Terra Preta "Normal" soil



Nutrient retention is important in those areas where nutrient losses limit soil productivity, such as on highly weathered soils in the humid tropics, or where nutrient losses have detrimental off-site effects, such as with agrochemical contamination of ground- and surface waters. Under extremely adverse soil conditions, crop productivity can be increased several times with a comparatively simple application of bio-char. Acid soils can be ameliorated where conventional liming is prohibitively expensive, and fertilizer efficiency is drastically improved.

"...since I moved to my current home and farm on Terra Preta, I have not been sick anymore as before. Also my family is now much healthier."



Dona Francisca, Rio Urubu, 2004

Not only can crop yields be improved, but cropping systems can be changed in ways that were not possible before. Instead of being constrained to acid-tolerant and low-demanding crops such as manioc, small farmers can engage in cropping higher value produce such as vegetables. These opportunities not only improve farm income through sales of produce but also farmers' health through better nutrition.

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Soil Fertility

The application of bio-char improves soil fertility by two mechanisms: (1) by adding nutrients to soil (such as K, to a limited extent P and micronutrients); (2) by retaining nutrients from other sources including nutrients from the soil itself. The main advantage is the second, the enhanced nutrient retention mechanism. In most situations, the bio-char additions have a net positive effect on crop growth only if nutrients from other sources such as inorganic or organic fertilizers are applied as well.



Carbon Sequestration

Bio-char (biomass-derived black carbon) is highly stable in soil and can persist hundreds and thousands of years. It is much more stable than even the most stabilized carbon in soil. It therefore constitutes a much longer carbon sink than most other sequestration options such as no-tillage, manure applications, or afforestation. If black carbon is buried in deep soils through leaching or in sea or ocean sediments, black carbon sequestration can be considered a permanent carbon sink.

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Literature on Terra Preta and Black Carbon Soil Management:
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Sombroek WG, Nachtergaele FO and Hebel A 1993 Amounts, dynamics and sequestering of carbon in tropical and subtropical soils. *Ambio* 22: 417-426.

Web page:
http://www.css.cornell.edu/faculty/lehmann/terra_preta/TerraPretahome.htm

Application of bio-char (biomass-derived black carbon or charcoal) has significant and long-lasting positive effects on soil fertility especially (but not limited to) where low soil organic matter and acid soils predominate. This is the case in many of the soils in the warm-humid tropics. Such a black carbon soil management can be incorporated into several land-based production systems that produce carbon, such as bio-fuel energy production, slash-and-char as an alternative to slash-and-burn, waste recycling of agricultural and charcoal production.

SLASH-AND-CHAR

In shifting cultivation, fallow or primary forest biomass is cut and burned to allow planting of crops. The ash resulting from the burn helps to sustain a few cropping cycles before the land has to revert back to fallow. In a slash-and-char adaptation of this shifting cultivation system, the identical amount of biomass would be used and instead of being completely burnt about 50% of the biomass carbon can be retained in the form of bio-char and added to soil.



AGRICULTURAL WASTE

Millions of tons of agricultural wastes are discarded annually including wastes from charcoal production, yard and municipal park trimmings, crop residues, forestry or wood processing industries. These resources can be used to produce black carbon (or used as is in the case of charcoal) and applied to soil. Not all materials are useful for the production of bio-char, but surprisingly many are. While corn residue is less appropriate, peanut shells or rice husks are ideal.

BIOENERGY PRODUCTION

Agricultural wastes as well as bio-energy crops can be used to produce energy by charring them in specialized power plants and yield bio-char as a by-product. The majority of the energy is converted into hydrogen, bio-oil or electricity. Due to favorable energetic processes, the efficiency of the energy production is very large while carbon retention is high due to additional stripping of emissions of flue gas. This is a revolutionary process by which energy production can become a net sink of atmospheric carbon dioxide and provide organic matter to enrich our soils.