Soil health and Biochar

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Most organic matter is 45 to 50% Carbon by weight and normal burning in Oxygen releases all this C as CO₂ to the atmosphere. By restricting Oxygen, about 50% of the C is retained in the biochar, while the other half is released.

Biochar is the solid residue formed by controlled pyrolysis of organic matter in low/no oxygen environment.

Biochar has physio-chemical properties suitable for carbon storage and soil improvement.
What feedstocks can be used to manufacture biochar for the soil?

- Woody waste from agriculture, horticulture, forestry
- Vegetable waste
- Manures

Considerations:
- Conversion temp
- Lignin content
- Particle size
- Moisture content
Biochar – How is it made?

Varies scales of pyrolysis units that are linking climate-smart agriculture with sustainable energy and health

Jimma
Biochar internal structure
Biochar benefits

- Reduced methane soil emissions
- Reduced N₂O soil emissions
- Carbon negative energy
- Reduced odor
- Carbon capture
- Atmospheric benefits

BIOCHAR

Viable Sustainable

Soil benefits
- Decreased nutrient runoff
- Increased soil carbon
- Improved soil fertility
- Improved soil tilth
Biochar in the soil

Features
• Holds onto moisture, up to 6x its own weight
• Mild CEC – improved nutrient delivery
• Substrate to provide habitat & refuge for soil microbes
• Improves soil structure
• Mild liming effect
• Stable carbon storage

Benefits
• Increases crop yields
• Reduces irrigation
• Reduces fertiliser use
• Reduces nutrient leaching
Biochar and Compost

Biochar as a compost additive and soil amendment
Disease resistance

Increased income

Sustainable land use

Higher yields

Climate resilient agriculture

Carbon capture

Additional income

UNDP
Biochar and Climate Smart Agriculture

An emerging solution is 'climate-smart' agriculture - farming which improves productivity, increases resilience to climate change and reduces GHG emissions. - PWC

BIOCHAR PROJECTS DELIVER SUPPLY CHAIN RESILIENCE

- Increased productivity / yields
- Climate resilient agriculture practices
- Carbon mitigation
Biochar technology in sub-Saharan Africa

• Benefits from biochar amendments are expected to show readily in inherently infertile soils with low organic carbon (Lehmann et al., 2003).

• Soils in smallholder cropping systems in sub-Saharan Africa (SSA) are inherently poor, characterized by low pH, low inherent soil fertility and organic matter and low water holding capacity and thus could benefit greatly from biochar application.

• Research on biochar use in Africa is still in its infancy (Torres, 2011; Torres-Rojas et al., 2011).

• In a field study conducted on degraded light (11-14% clay) and heavier (45-49% clay) textured ultisol soil, addition of wood biochar (6 ton C ha⁻¹) more than doubled maize yields in West Kenya (Kimetuet al., 2008).
Summary depiction of biochar technology in sub-Saharan Africa

A: Feedstocks
- Centralized (C) & Decentralized (D):
  - Sludge (C)
  - Municipal solid waste (C/D)
  - Forest residues (C)
  - Agro-processing wastes (C)
  - Crop residues (C/D)
  - Manure (C/D)
  - Aquatic weeds (C)
  - Firewood (D)

B: Pyrolysis
- Continuous (medium/large scale):
  - Screw-type
  - Rotary kilns
  - Drum pyrolysers

- Batch (small-scale decentralized):
  - Drum kiln
  - Pyrolytic cookstoves

C: Applications
- Agriculture
- Environment
- Energy

D: Impacts
1. Crop productivity (+)
2. Soil fertility (+)
3. Carbon sequestration (+)
4. Greenhouse gas emission (+/-)
5. Remediation of contaminated land (?)
6. Environmental & public health risks (?)
7. Provision of cheap & clean energy (+/-)
8. Air quality (+/-)

Impacts:
(+): positive
(-): negative
(+/-): positive/negative (i.e. inconsistent)
(?): Unknown/no evidence
Biochar-based bio-fertilizer development using locally available agricultural and agro-industrial waste streams in Ethiopia

Presented at Jimma by Dr. Dawit
Competitive uses of agricultural waste in Ethiopia
Field trial results

- Bone char provided 40% of the recommended P input
- Bone char more than doubled the farmers’ yield in on-farm trials
- Use of bone char resulted in 40% saving for farmers by reducing the cost of production allocated for commercial fertilizers
Biochar production
- Need to know the soil
- Production constraints
- Optimize production parameters to produce targeted biochar
What we do then?

- Biochar use in soil is a new strategy, with many unknowns and uncertainties. Adding biochar to soil should be an experiment, done carefully, thoughtfully, with orderly planning, application, observation, measurement of results, and documentation.
Features of typical biochar system design

• Local project team
  — Growers cooperative
• Identify feedstock from the waste stream
• Set up production system
• Process biochar to soil amendment
  — Product formulations / application methodologies
• Set up crop trials
  — Implement
Guidelines to prepare and use of biochar

• Biochar Description
  – physical, chemical & biological properties—particle size, PH, micropors, moisture, minerals, O/C and H/C ratio of the raw material, Temperature, Ash, and microbes.
    – www.carbon-negative.us/characterization

• Field Trial Design
  - small test plots are always advised before large scale applications.
    www.carbonnegative.us/FieldTrialGuide

• Transport & Handling
  - moisten char with water, or blend with compost or other moist matter.
  - Pelletizing, granulation conserve char to assure its delivery to soil.

• Toxicity
  - Seed germination
  - Earthworm Avoidance
• Biochar Preparation
  – Moisture,
  – Size Reduction,
  – Mineralization,
  – Inoculation

• Application
  - Rates: Per acre, this amounts to 10 to 20 tons. Successive applications over a few years are advised instead of adding a large amount all in one year.
  - Methods
  - Equipment

• Field Trial Registration
  - Fill out the Field Trial Data Sheet and share with others.
  www.carbon-negative.us/DataSheet
Current and future challenges in biochar research

• main problems preventing a widespread adoption of biochar are:
  – **to tailor a single biochar with a particular soil and crop type.** This task will require a deeper mechanistic understanding of the processes involved in the biochar-soil-plant interaction.
  – **obtain a best biochar with similar properties to other soil amendments.** This require a perfect knowledge of the parameters involved on biochar production.
  – **Variability of Biochar composition and stability**
  – **Small scale technologies relevant for its production:** answering both technical and socio-economic aspects.