# Bio char Characteristics, Properties and Uses in Crop Production

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## Managing Crop Residues

- Huge quantities of unused and excess crop and agro forestry residues in India are of concern due to inefficient crop residue management practices
- Direct incorporation of crop residues into agricultural soils
- Conserve soil nutrients and organic carbon content
- Causes considerable crop management problems due to delay in decomposition
- Surplus crop residues when left unattended, often disrupt land preparation, crop establishment and early crop growth,

## Open Burning of Crop Residues

- Burning of crop residues is often practiced on farm but causes environmental problems and substantial nutrient losses
- Open field burning of crop residues is an age old practice to boost soil fertility in terms of P and K, Often leads to a loss of other nutrients (*e.g.* N and S), organic matter and microbial activity
- Maintenance of a threshold level of organic matter in rainfed soil is crucial to sustain soil physical, chemical and biological activities to achieve optimum agricultural production and environmental functions
- A more effective and economically effective management and disposal of the crop and agroforestry residues, is their conversion into biochar through thermo-chemical process or slow pyrolysis
- Improve soil health through efficient use of crop residue as a source of soil amendment/nutrients

## Advantages of conversion of agro waste to biochar

- improve soil physical properties *viz.,* bulk density, porosity, water holding capacity, drainage *etc,*
- Substantial amounts of carbon can be sequestered in soils in a very stable form
- Enhances soil nutrient use efficiency and microbial activity
- Improved soil and water conservation in rainfed areas
- Minimize reliance on external amendments for ensuring sustainable crop production
- Mitigation of greenhouse gas emissions by avoiding direct crop residue burning
- Destruction of all crop residue borne pathogens
- Conversion to biochar helps to reduce the bulkiness both in terms of weight and volume
- Easy to handle compared to that of fresh and uncarbonized residue

## What is biochar

- Biochar is the black carbon or charcoal made from biomass—biological, organic materials derived from plants and animals.
- Prepared by heating biomass in an environment that has little or no oxygen at temperature ranging from 350-600$^0$ C a process called pyrolysis.
- The net effect of pyrolysis is the production of a solid material (biochar) that has a high concentration of carbon and does not easily break down in the soil.
- Application of  biochar to the soil, increases  the soil's carbon content significantly
- Added carbon persist in the soil for a very long time - carbon sequestration.

# History of Biochar

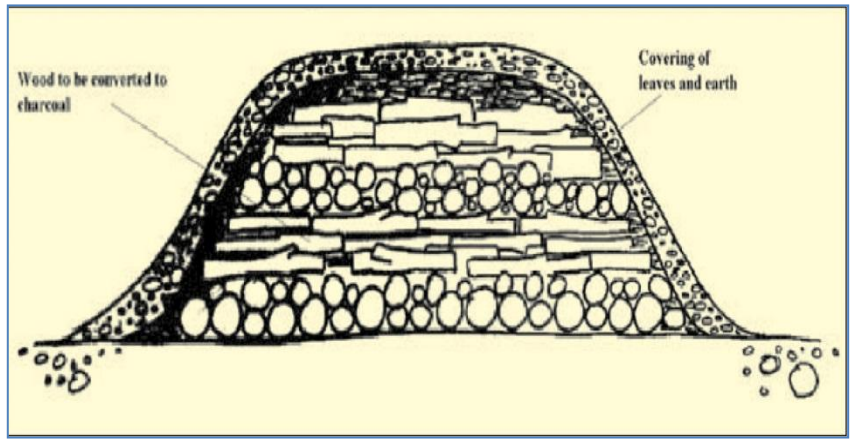
- Biochar, and the idea of applying charred organic materials to soils, is not new (Lehmann and Joseph, 2015).
- Japanese horticulture has a tradition of applying wood chars to soils to improve plant growth. Agriculture and waste management manuscripts from Europe in the 19th century include charcoals as recommendations of potential “manures” for field applications (Wilson, 2013).
- Modern study of biochar stems from investigations of *terra preta*, or anthropogenic (human-made) black earths.
- Soils of the Amazon  are in general infertile and soils with terrapreta were more fertile
- Soils with Terrapreta comprised of the black carbon accumulated over thousands of years
- Study of soil properties showed three times more soil organic carbon than native soil
- Better soil fertility as measured by higher CEC, neutral pH, available nutrients, moisture retention and microbial population

## Preparation of biochar

- Can be produced at scales ranging from large industrial facilities down to the individual farm.
- To make biochar technology popular among the farmers, low cost biochar kiln at community level have to be installed (Natarajan et al, Pharma journal,2021; 10(6): 544-551)
- Heap and drum methods are commonly used at the farm level for biochar preparation.
- Both methods are comparatively easy to prepare,cheap and can be popularized among farmers

Biochar from Prosophis

Biochar  Earthern Mound Kiln




Preparation of Biochar Heap method

## Properties of Biochar

- Properties vary with nature of agro wastes usd and pyrolysis temperature
- Low bulk density due to porous structure
- High surface area ranging from 50 – 900 $m^2$/ g
- Black colour is due to its poly condensed aromatic structure as a result of dehydration during thermo chemical conversion.
- Structure is also responsible for its relative recalcitrance compared to raw agro wastes
- High pH values of biochar due to hydrolysis of carbonates and bicarbonates of basic cations Ca, Mg, Na and K present in the source materials
- High cation exchange capacity (CEC) and charge density attributed to oxidation of functional group on biochar particles
- High cation exchange capacity enables high retention of plant nutrients in available form

## Properties of Biochar (Jha et al. 2010)

| Material | pH | Total C (%) | Total N (%) | C:N ratio | c mol $kg^{-1}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ca | Mg | P | K | CEC |
| Farm waste(grass & plant prunings) | 9.4 | 36.0 | 0.18 | 200 | 0.4 | 0.56 | - | 21 | 24 |
| Poultry litter | 9.9 | 38.0 | 2.0 | 19 | - | - | 37.2 | - | - |
| Wood | 9.2 | 72.9 | 0.76 | 120 | 0.83 | 0.2 | .10 | 1.9 | 11.9 |

**Physical**

- Decreases bulk density and improves soil workability,
- Reduces labour and tractor tillage thus minimizing fuel emissions
- High negative charge promotes soil aggregation and structure
- Retain plant available soil moisture due to its high surface area and porosity

**Chemical**

- Liming effect enables better nutrient availability by reducing acidity
- Enhance the fertilizer use efficiency,thus reducing input cost
- Improves the bioavailability of phosphorus and sulphur
- Reduce leaching of nutrients and prevents groundwater contamination
- Stable carbon in biochar has longer residence period and reduces Green House Gas emissions
- High surface area, porous structure enables greater nutrient retentive capacity

**Biological**

- Enhanced microbial activity and diversity of beneficial soil bacteria, actinomycete and arbuscular mycorrhiza fungi
- Porous nature provides favorable microhabitats and protection from drought,competition and predation

**Mitigation of climate change**

- A number of studies have reported on environmental benefits of biochar additions which will reduce emission of non-CO2 greenhouse gases from soil
- Due to inhibition of either stage of nitrification and or inhibition of denitrification,
- Reduction of N2O, increases CH4 uptake from soil and long-term carbon sequestration in soil
- In India, biochar from residues of maize, castor, cotton and pigeonpea sequester about 4.6 Mt of total carbon annually in soil,

**Crop production**

- Several workers have reported positive responses for crop production in terms of grain yield and dry matter
- Response is greater in highly degraded acidic or nutrient depleted soils
- Application in low doses of 0.5t/ha tons per have shown marked impact on various crops
- Standardization of doses for various crops has to be taken up in tropical soils
- Biochar application in combination with inorganic or organic manures seems a better option in fertility management
- **Nutrient use effeciency**
- Properties of biochar in amending soil pH, improving cation absorbing capacity and moisture retention enhances the nutrient use efficiency
- Immediate beneficial effects include greater availability of potassium, phosphorus and zinc availability and to a lesser extent of calcium and copper
- Enhanced biological N fixation and in pulse crops,and attracting more beneficial fungi and microbes have been reported in biochar amended soil

## Soil microbial activity

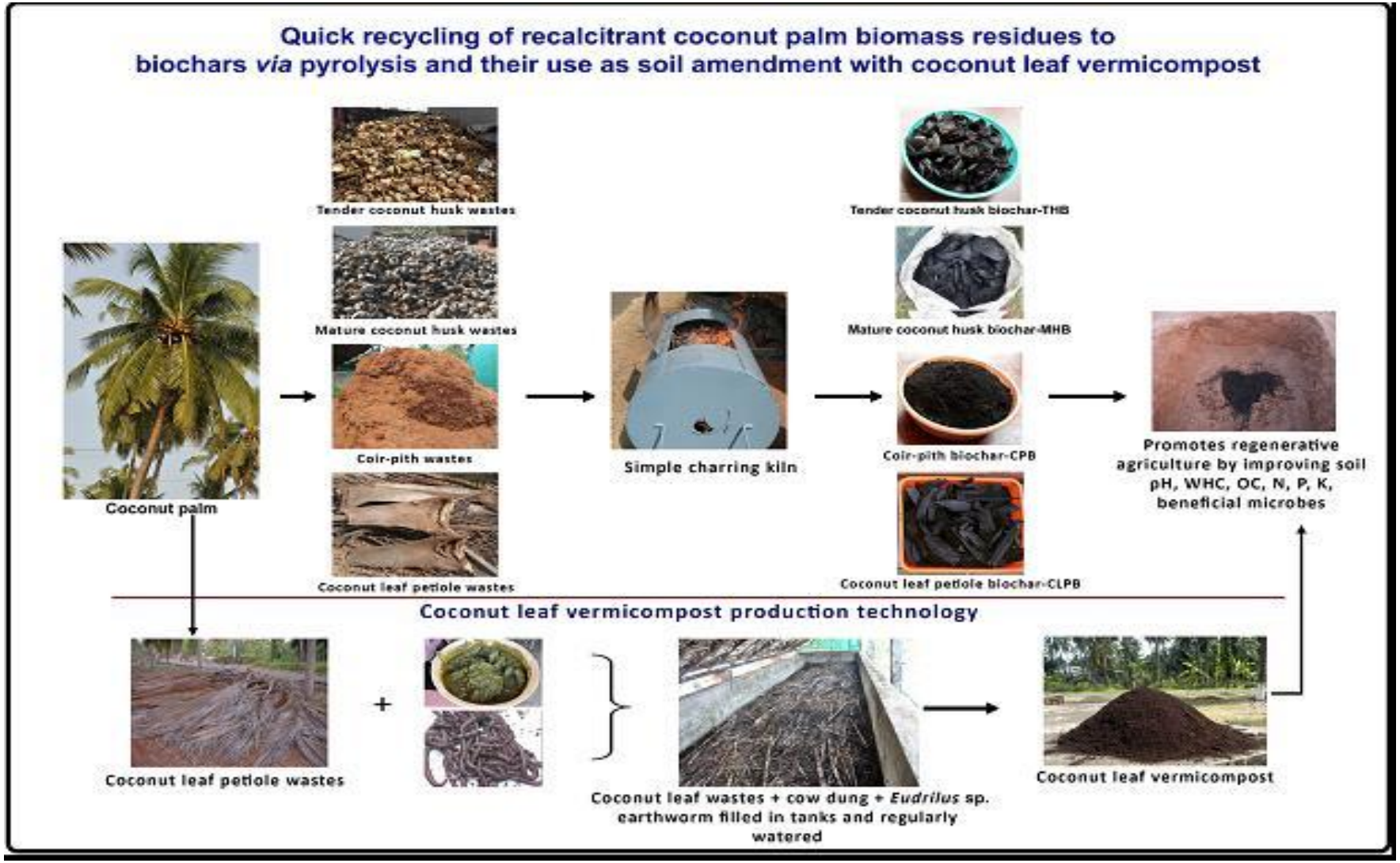
- Biochar provides a suitable habitat for a large and diverse group of soil microorganisms.
- Higher activity and diversity of microorganisms in biochar amended soils due to a high surface area as well as surface hydrophobic properties
- Strong affinity of microbes to biochar is due to increased adhesion of solids due to hydrophobic properties
- Inherent porous nature, improved soil porosity,surface area and soil aeration, improves microbial activity
- Improved microbial population and diversity contributes to greater release and availability of N, P, K , S and other nutrients
- All these factors contribute to lesser fertilizer doses
- Increased enzyme activity an indirect index of microbial activity in terms of acid and alkaline, phosphatase, dehydrogenase have been reported in biochar amended soil

## Future lines of work

- Research information on biochar in agricultural use in India is scanty
- Production and characterization of  biochar from different agro wastes
- Production methods with focus on farmer level methods
- Time ,method of application and dose to be standardized for various crops
- Biochar based nutrient fortification  as part of composting
- Nutrient release pattern  of fortified biochar in different soils  to be standardized

**Reference**

**G, Pratibha G, Srinivasarao Ch, Ravindra Chary G, Prabhakar M, Visha Kumari V, Shankar AK and Venkateswarlu B. 2018. Biochar Production and its Use in Rainfed Agriculture:Experiences from CRIDA. CRIDA-NICRA Research Bulletin 02/2018, ICAR - Central Research Institute for Dryland Agriculture, Hyderabad.**


Quick recycling of recalcitrant coconut palm biomass residues to biochars *via* pyrolysis and their use as soil amendment with coconut leaf vermicompost
Tender coconut husk wastes
Mature coconut husk wastes
Coir-pith wastes
Coconut leaf petiole wastes
Coconut palm
Simple charring kiln
Tender coconut husk biochar-THB
Mature coconut husk biochar-MHB
Coir-pith biochar-CPB
Coconut leaf petiole biochar-CLPB
Promotes regenerative agriculture by improving soil pH, WHC, OC, N, P, K, beneficial microbes
Coconut leaf vermicompost production technology
Coconut leaf petiole wastes
+
Coconut leaf wastes + cow dung + *Eudrilus* sp. earthworm filled in tanks and regularly watered
Coconut leaf vermicompost


Thank You