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Role of Biochar in Agriculture

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Introduction:

Depletion of Soil Organic matter and losses of soil nutrients in changing climate situations are posing threats to the sustainability of agricultural production. Indian soils are deficient in soil organic carbon content *i.e.*< 0.5% organic carbon in most of the Indian soil. Diminishing trends of soil fertility are due to deterioration of soil organic carbon, which leads decline in agricultural productivity. Improvement of soil organic carbon content is achieved through the application of organic matter and manure in the soil. Among organic materials, the biochar as soil amendments are used to improve soil fertility and health.

"Biochar" is a fine-grained, charcoal product remaining after plant biomass has been subjected to pyrolysis process (thermochemical conversion) at low temperatures ~350–600°C in little or no oxygen conditions. The biochar usually representing about 50% of the carbon content of biomass and hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions. These proportions and properties of biochar can change extensively, depending on the temperature and biomass used during the pyrolysis process. Biochar is a material formed by natural biomass burning creates black which forms a considerable proportion of Ash, Labile carbon and Recalcitrant carbon are the core components of Biochar. It is the contemporary improvement, evolving in combination with soil managing, carbon confiscation or sequestration matters and immobilization of contaminants. Some biochar can have characteristics which makes them an excellent amendment in one soil but not the biochar can simply awful. Biochar has great potential for climate change mitigation and soil equality improvement for sustaining food security for the future generation.

Biochar Production

Biochar can be manufactured on a small scale using lower modified stoves or kilns, cost intensive production which utilizes larger pyrolysis plants and a higher amount of feedstocks. Feed material - Crop residues, wood logs, roots, shoots, leaves of plants. The biochar usually, representing about 50% of the carbon content of biomass. Gasification liberates more energy rich syngas from the char (usually hydrogen-based). The biofuel is often syngas, which is a mixture of mainly hydrogen and carbon monoxide with a little CO_2. The dry waste obtained is simply cut into small pieces to less than 3 cm prior to use. The feedstock is heated either without oxygen or with little oxygen at a temperature of 300-700°C. Pyrolysis is generally classified by the temperature and time duration of heavy last pyrolysis takes place at a temperature above 500°C and typically in seconds. This condition maximizes the generation of bio-oil. Slow pyrolysis, on the other hand, usually takes more time, from 30 min to few hours for the stock to fully pyrolyze and at the same time yields more biochar. The yield of biochar from slow pyrolysis of biomass has been stated to be in the range of 24.77% where the yield of biochar from fast pyrolysis is 10-20%.

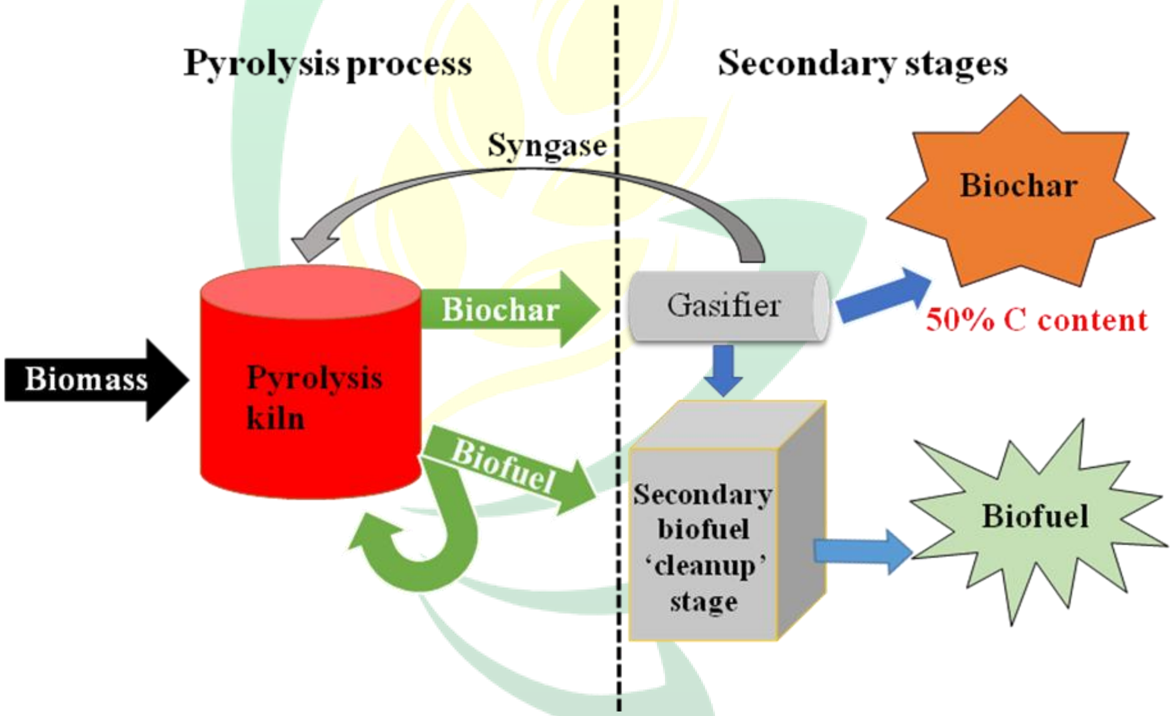

Fig.1. Simplified pyrolysis process flow diagram

Influence of Biochar on Soil Physical and Chemical Properties:

The central quality of biochar that makes it attractive as a soil amendment is its highly porous structure, potentially responsible for improved water retention and increased soil surface area. Soil physical parameters such as wettability of soil, water infiltration, particle size, porosity, specific surface area, macro-aggregation and soil stability have been improved

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with the application of biochar. It also has importance in tropical environments to combat erosion, mitigating drought and nutrient loss and in general enhancing the groundwater quality. The application of biochar also influences the chemical properties of soil like pH, cation exchange capacity, electrical conductivity, organic carbon content, C:N ratio and nutrient content. It increases soil pH, organic carbon, cation exchange capacity and nutrient retention capacity of the soil. It also enhances natural rates of carbon sequestration in the soil, reduces greenhouse gases (GHG) emissions and improves the soil quality.

Influence of Biochar on Nutrient Use Efficiency:

Biochar application boosts soil fertility and improves soil quality by raising soil pH, increasing moisture holding capacity, attracting more beneficial microbes, improving cation exchange capacity and retaining nutrients in the soil. Long term benefits of biochar application on nutrient availability mainly due to greater stabilization of organic matter, concurrent slower nutrient release from added organic matter and better retention of all cations due to greater cation exchange capacity. The enhanced nutrient retention capacity of biochar-amended soil not only reduces the total fertilizer requirements but also increases the availability of nutrients. It helps to increase nitrogen fixation in pulses, the bioavailability of P and also increased the availability of secondary and micronutrients.

Benefits of biochar:

1. It increases cation exchange capacity.
2. It improves soil water holding capacity.
3. It supports soil microbial life and biodiversity.
4. Biochar has the potential to reduce greenhouse gas emissions through carbon sequestration, as well as the potential of decreasing methane and nitrous oxide emissions from the soil.
5. It helps plants resist diseases and pathogens.
6. It stimulates symbiotic nitrogen fixation in legumes.
7. Better nitrogen use efficiency and crop productivity can be obtained with biochar use.
8. It enhances plant growth and crop yields.
9. It reduces soil acidity by raising soil pH.
10. Application of biochar reduces leaching of nutrients.

Drawbacks of biochar.

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1. The heterogeneous nature of biochar, cost of production of biochar for research and field application is likely to remain a constraint until commercial-scale pyrolysis facilities are established.
2. Unavailability of farm labour, higher wage rates for collection and processing of crop residue, lack of appropriate farm machines for on-farm recycling of crop residue and inadequate policy support/ incentives for crop residue recycling.
3. Biochar may decrease aggregate stability as it does not contain binding substances like non-charcoal organic matter.
4. High C:N ratio of biochar may result in the immobilization of nitrogen making it unavailable to plants.
5. The increase in cation exchange capacity depends on the composition of the soil it is minimal in soils with high clay (or) organic matter content.
6 Sorption and accumulation of toxic compounds may occur, eg. pesticides, herbicides, poly-aromatic hydrocarbons, heavy metals and volatile organic compounds, dissolved organic carbon.

Conclusion

- Application of biochar to agricultural land for soil amelioration and agricultural productivity improvement
- It has been found to improve soil parameters such as soil pH, cation exchange capacity and soil water holding capacity.
- Better nitrogen use efficiency and crop productivity can be obtained with biochar use.
- Biochar has the potential to reduce greenhouse gas emissions through carbon sequestration, as well as the potential of decreasing methane and nitrous oxide emissions from the soil.
- Need to explore biochar interaction under different soil types with respect to change in nutrient cycle, soil physical properties and biochemical properties.
- Whether the inclusion of biochar in the cropping system would bring more abetment of greenhouse emission over long term scale in agriculture
- What would be a long-term effect upon field application on soils and crops and with the applied biochar.

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