e ISSN–2321–7987 | ●●● Article ●●● |Visit us : *www.researchjournal.co.in*|

Biochar for future food security: An overview

Vikas Abrol, **Peeyush Sharma and** Vishaw Vikas

Division of Soil Science and Agricultural Chemistry, ACRA (SKUAST-J), Rakh Dhiansar, JAMMU (J&K) INDIA

Global climate change is the primary important factor for agricultural production and one of the most urgent environmental problems. Agricultural soil is dynamic biological system that both stores and releases greenhouse gases. This makes soils an important source of greenhouse gases but also a potential sink if right management is applied. Climate change mitigation impacts arise largely from the stabilisation of soil organic matter, the reduction in fertilizer requirements and gaseous emissions in soils, and the production of renewable energy which can displace fossil fuel consumption. Biochar application may improve the soil health and reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases. Converting biomass to biochar offers an excellent method for reducing waste and using these byproducts

Biochar is one of the viable organic amendments to combat climate change and sustain the soil health with sustainable crop production. Biochar may be added to soils with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases. Biochar also has appreciable carbon sequestration value. Biochar application may improve the physical, chemical and biological properties of soils, reduce fertilizer requirements and stimulate plant growth, though the results vary between biochars, soil types and plant species. The effectiveness of biochar for the improvement of soil properties is influenced by the biomass feedstock and the pyrolysis conditions Biochar also has appreciable carbon sequestration value.

Climate is an important factor of agricultural productivity. Climate change is caused by the release of 'greenhouse' gases into the atmosphere. Agriculture produces CO_2, CH_4 and N_2O which is directly or indirectly due to the burning of non-renewable resources (carbon bound in mineral oil or coal). While CO_2 is the primary gas emitted by most other industries, the primary greenhouse gases emitted by agriculture are CH_4 and N_2O. Agriculture contributes to over 20 per cent of global anthropogenic greenhouse gas emissions. The change in temperature and rainfall patterns is also damaging the organic matter, physical structure and the populations of soil organisms. The large increase in the use of nitrogen fertilizer for the production of crops has dramatically increased the emissions of nitrous oxide, a powerful greenhouse gas, while the gasoline and diesel fuel that is consumed by tractors and trucks is also a large source of carbon emissions. Soils contain 3.3 times more carbon than the atmosphere and 4.5 times more than plants and animals on earth. This makes soils an important source of greenhouse gases but also a major sinks and helps to sequester more carbon and cut the N_2O emission by adopting right soil and crop management techniques. The world population is currently increasing at a fast rate and is expected to reach 9 billion by 2050. To meet a growing demand for food from a growing population, we need to increase agricultural productivity upto 70 per cent, and food production in the developing world will need to *double* by 2050 (FAO). In recent years biochar application gained momentum because of its unique ability to help build soil, improves soil physical condition, enhancing nutrient uptake from the soil and to reduce nitrous oxide emission and sequester carbon.

Biochar : Biochar is a solid material produced by a thermochemical decomposition process. This process is called pyrolysis, which consists of heating biomass at a high temperature (≈400 – 800^{0}C) in a limited oxygen environment. Pyrolysis is the chemical decomposition of an organic substance by heating in the absence of oxygen. The word is derived from Greek word 'pyro' meaning fire and "lysis" meaning decomposition or breaking down into constituent parts. Biochar first came into broad public awareness through the example of the Amazon, where the hypothesis is that Amazonian inhabitants added biochar along with other organic and household wastes over centuries to modify the surface soil horizon into a highly productive and fertile soil called terra preta (dark earth), which is in direct contrast to the typical weathered Oxisol soils in close proximity. Biochar, also known as black carbon, is a product derived from organic materials rich in carbon (C) and is found in soils in very stable solid forms, often as deposits. Biochar, a soil amendment, has potential as a valuable tool for the agricultural industry with its unique ability to help build soil, conserve water, produce renewable energy and sequester carbon. Biochar can be created from a wide variety of feedstocks (as

straw, nut shells, rice hulls, wood chips, wood pellets, tree bark and manure). Studies sponsored by the Ministry of New and Renewable Energy (MNRE), Govt. of India have estimated surplus biomass availability (Fig. 1). Feedstock, along with pyrolysis conditions, the most important factor controlling the properties of the resulting biochar. Rice husk and rice straw contain unusually high levels of silica (220 and 170 g kg^{-1}) compared to that in other major crops. As a soil amendment, biochar significantly increases the efficiency of and reduces the need for traditional chemical fertilizers, while greatly enhancing crop yields. The carbon in biochar resists degradation and can hold carbon in soils for hundreds to thousands of years.

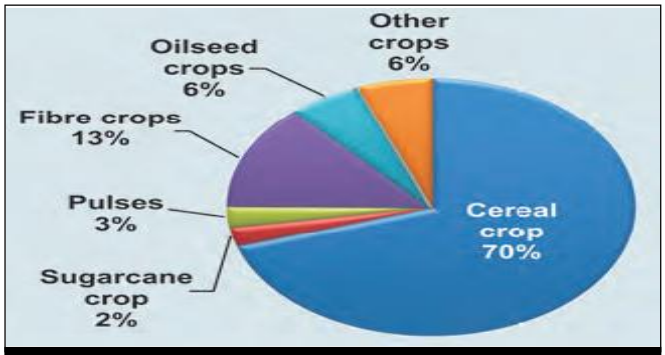


Fig. 1 : Residue generation by different crops in India (calculated from MNRE, 2009)

How is biochar made ? :

Material required:

– *Metal container* : Needs to be tight-closing and sturdy as it will be acting as 'biochar cooker'.

– *Organic material for 'charring'* : Leaves, Twigs, wood chips , manure etc

– *Fire place/pit/drum* : A drum or pit will work better as it uses less fuel and creates greater heat intensity- charring quicker and better.

Stemps :

– Tight-fitting containers, which are essential, but there should be "escape holes" because under extreme heat the pressure inside the containers would potentially force them to explode.

– Although the fire in drum takes longer to create glowing embers (due to less oxygen exposure than an open fire), the heat intensity is eventually far greater and also uses less fuel for it.

– Depending on the container, woods used, heat intensity of fire etc., the time to char will be variable. Notice a plume of what looks like smoke coming from the hole in the container- this is actually the gases of the wood.

– Once cooled, check charring is consistent all the way throug., keep them in a tight container and somewhere dry until use

Impacts on soil : Soil carbon levels have decreased under agricultural land use. Research revealed that minimum or no-tillage practices, mixed farming with manure amendment leads to higher organic matter levels in soil. Soil is a part of the natural world that is both affected by and contributing to global warming. Soil is the one of the largest sources of carbon in the world. It is primarily accumulated through plants which 'fix' the carbon from carbon dioxide in the air; the soil then directly absorbs the carbon as the plants decay. Additionally, dead leaves and animals are broken down by microbes in the soil and carbon is accumulated. 2.2 gigatons of C can be stored in the soil by 2050 using biochar conversion technologies, according to the International Biochar Initiative (*http://www.biochar-international.org/biochar*). Biochar is highly porous, thus the addition of soil is considered to improve a range of soil physical properties including total porosity, pore-size distribution, soil density, water holding capacity or plant available water content, and infiltration. Biochar can retain applied fertilizer and nutrients and release them to agronomic crops over time. Biochars' ability to retain water and nutrients in the surface soil horizons for long periods benefits agriculture by reducing nutrients leaching from the crop root zone, potentially improving crop yields, and reducing fertilizer requirements. Additionally, biochar could improve food production in the world's poorest regions as it increases soil fertility.

Impact on climate change : In addition to agronomic benefits there is a great interest in the climate change mitigation potential of biochar as its capability to sequester soil carbon over a long time. Under normal circumstances CO_2 is removed from the atmosphere by photosynthesis

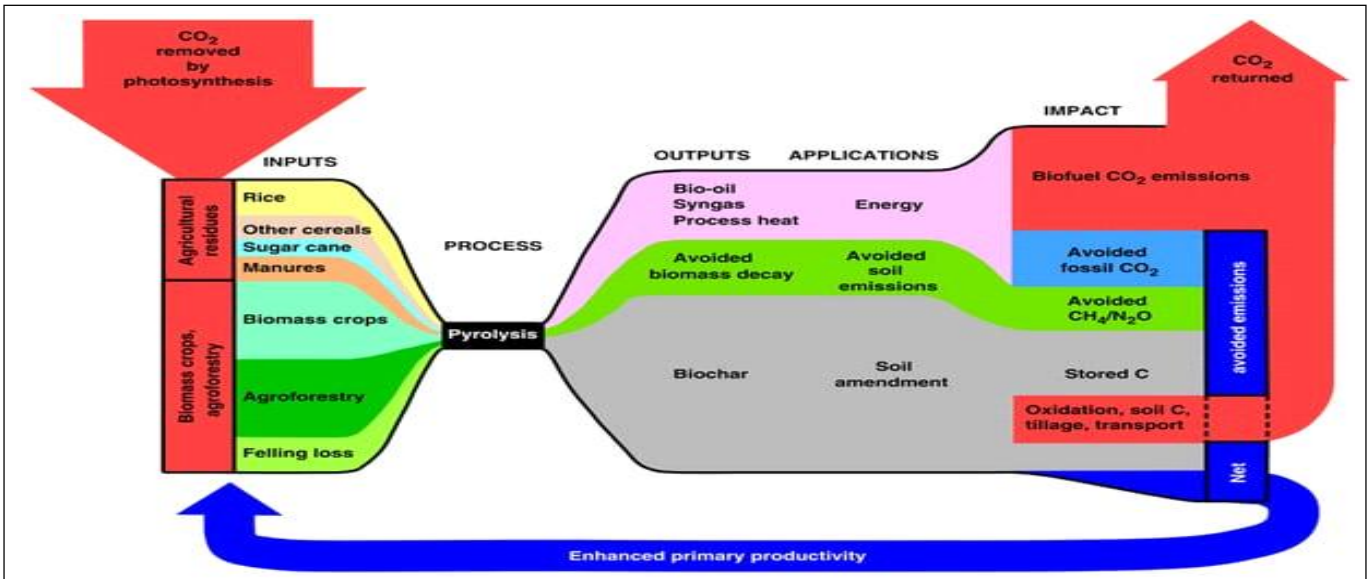
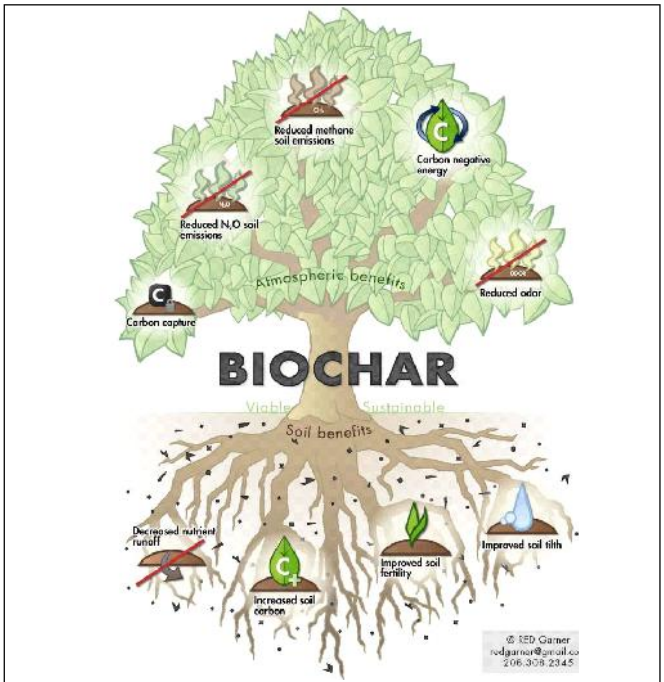


Fig. 2 : Input , process, output, applications and impacts on global warming (Image: Nature Material)

and added to the soil in the form of organic matter, then as the organic matter decomposes CO_2 is released back into the atmosphere though microbial respiration. The pyrolysis of organic matter results in a form of carbon with an altered chemical structure (aromatic C rings) that is resistant to microbial decomposition, called recalcitrant or fixed carbon. When added to the soil this carbon is not readily decomposed and hence carbon remains in the soil and out of the atmosphere. This means that biochar allows carbon input into soil to be increased greatly compared to the carbon output through soil microbial respiration, and it is this that is the basis behind bio char's possible carbon negativity and hence its potential for climate change mitigation. According to a new study, as much as 12 per cent of the world's human-caused greenhouse gas emissions could be sustainably offset by producing biochar. One tonne of biochar is equivalent to 2.7 tonnes of carbon dioxide removed from the atmosphere. The World Bank has identified biochar as the most effective system of greenhouse gas abatement in soil when compared to all other sustainable land management practices.

The list of potential gains from applying biochar to soils that are reported in the literature is almost endless:

– Increased yields of up to a doubling
– Increased fertilizer efficiency
– Increased water retention
– Mitigation of climate change due to the sequestration of carbon in a resistant form, the reduction of the emissions of the potent greenhouse gases nitrous oxide and methane, production of renewable energy, etc.
– Disposal of green waste from agriculture and forestry
– Increased cation exchange capacity of the soil
– Biochar is extremely porous which allows it to retain nutrients and water — which plant roots can access when the biochar is added to soil.
– Increased soil pH (*i.e.* less acidic)
– Increased soil microbial biomass



www.biochar-international.org

Received : *24.01.2017* ***Revised :*** *06.05.2017* ***Accepted :*** *16.05.2017*