SUNSHINE AGRICULTURE e-Newsletter

ISSN (E): 2583 – 0821

Sun. Agri.:e- Newsletter, (2023) *3*(12), 24-27

Article ID: 261

Biochar: A Vital Amendment for Enhancing Environmental and Agricultural Sustainability

Rameshwar Choudhary[1*], Sunil Kumar Prajapati[2], Anand Kumar Diwakar[3], Rishabh Srivastava[4]

[1]Research Scholar, Department of soil science Punjab Agricultural University, Ludhiana, Punjab 141004, India
[2]Research Scholar, Division of Agronomy, ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi-110012, India
[3]Research Scholar, Department of Soil Science and Agricultural Chemistry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya 224229, (U.P.), India.
[4]Research Scholar, Division of Environmental Science, ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi-110012, India

Available online at
http://sunshineagriculture.vitalbiotech.org/

Article History
Received: 9. 12.2023
Revised: 15. 12.2023
Accepted: 20. 12.2023

INTRODUCTION

The term "biochar" is derived from the combination of 'bio' and 'char,' where 'bio' refers to ‘biomass’ and ‘char’ denotes 'charcoal.' Biochar, a stable carbon-rich substrate, is obtained through the pyrolysis of organic biomass or agricultural residues under low or no oxygen conditions. In this production process, bio-oil and gases serve as valuable byproducts for various industrial applications. Functioning as a carbon-rich charcoal, biochar is a result of the thermal decomposition of organic biomass or agricultural residues, serving as a soil conditioner. Comprising stable and labile components, major constituents of biochar include carbon (C), volatile matter, mineral matter, and ash. In recent years, the utilization of surplus organic matter or biomass, particularly from rice and wheat, in biochar production has shown promising outcomes in reducing CO^2 levels and mitigating climate change. Biochar proves effective in amending acidic soils, increasing their basicity, and enhancing overall agricultural productivity. Ongoing research explores various aspects of biochar, including its production, elemental composition, differences based on feedstocks, impact on soil carbon sequestration, and its role in reducing heavy metal pollution and mitigating climate change. In agriculture, biochar offers diverse benefits, including soil fertility enhancement, improved water retention, pH regulation, water conservation, microbial support, carbon sequestration, waste utilization, livestock bedding, soil remediation, and enhanced seed performance. Positioned as a vital product, biochar plays a crucial role in promoting both environmental and agricultural sustainability. With its versatile applications, biochar significantly contributes to soil improvement, pollution mitigation, and overall ecological resilience, providing a promising avenue for sustainable practices.

ISSN (E): 2583 – 0821

In the realm of sustainable practices, biochar emerges as a pivotal player, offering a multi-faceted solution for environmental and agricultural challenges, addressing issues such as pollution and climate change by enhancing soil fertility. This introduction emphasizes the versatile applications of biochar and underscores its crucial role in fostering environmental and agricultural sustainability.

2. Production

Biochar production is thermo-chemical conversion of biomass under low or no oxygen environment. There are different steps (fast pyrolysis, slow pyrolysis, gasification, and carbonization) involved in the production of biochar.

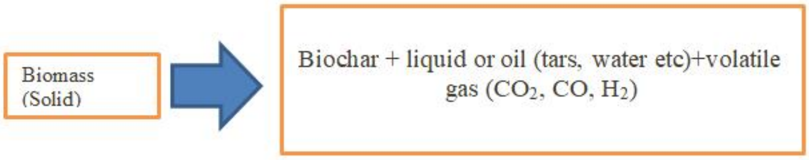

Fig 1 Biochar Production

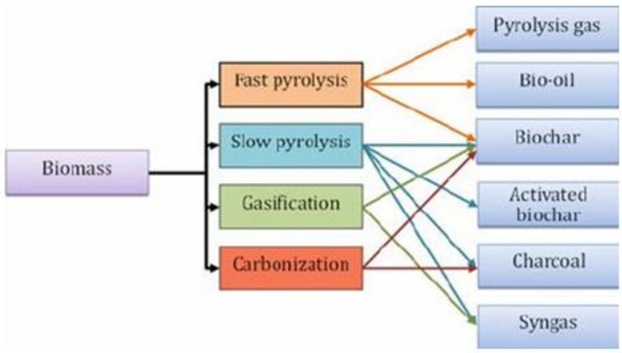

Fig 2 Step by step process for biochar production

3. **Biochar composition**: Biochar composition is affected by raw materials which are used for biochar preparations. Feedstocks which are rich in carbon and nitrogen have more carbon and nitrogen concentration in biochar. Researches have been done for comparing different biochars (derived from different sources) regarding their elemental and functional properties. Researches were carried out on effects of different feedstocks (wheat straw and rice straw) on nutritional composition of biochar and it was found that rice straw biochar is rich in nutrient content with respect to wheat straw biochar.

4. **Sources**: Rural areas are the main sources of raw material for biochar production, which includes crop residue from the harvesting of crops, charcoal from chulhas (villages), rice husk by products, different forest wastes, weed biomass, etc.

5. **Amendment of Soil and Environment through Biochar**

Burning of rice straw is a major problem all over the world, causing nuisance in the environment, soil and human health. In India, Punjab is the major rice-wheat growing state, where the area under paddy (rice) is approximately 3.0 million ha, which produces 20 million tons of paddy straw, out of which 75 per cent of the straw is burned in the fields only. Burning of rice straw generally gives rise to 1515 kg per tons of CO_2, 92 kg/tons of CO, 3.83 kg/tons of NO_2, 0.4 kg/tons of SO_2, 2.7 kg/tons of CH_4, 199 kg/tons of ash and 5.7 kg/tons of non-methane volatized substances. These are the major greenhouse gases (GHG) contributing to global warming. So, its management becomes very imperative.

5.1 Waste management: The waste produced from various sectors like agriculture, industries, forest, animal and municipal solid waste can be managed by intelligent utilization, i.e., exploiting the pyrolysis technique for biochar production. The management of the waste in this way is not only sustainable to the environment, and cost effective, but also one of the best methods to curb the environment pollution. In India, about 130–150 million tons of agricultural waste like acacia wood, coconut shell, etc. are dumped without any use. This clearly indicates that the biochar production potential is very high.

5.2 Soil management: Biochar can be extensively used as an amendment in the fields, which not only improves the overall quality of the soil, nutrient cycling, and carbon sequestration but also helps in the curbing of soil pollution. It contains about 48 per cent carbon, 1 per cent nitrogen, 0.7 per cent phosphorous and 3.3 per cent potassium. There is no release of any harmful gases from the biochar. Soil biochar application offers the potential to stabilize carbon and recycling of nutrients present in the straw. Early trends suggest beneficial effects of biochar on crop yields (rice-wheat and potato-anion) and C content in soil. Biochar improves the soil water holding capacity and thus the water retention for a longer duration, which is attributed to the highly porous structure. The biochar addition will increase the soil pH and EC. This is due to the presence of ash residue that is dominated by carbonates of alkali and alkaline earth metals and some amount of silica, heavy metal and organic and inorganic nitrogen. Thus, it will have a liming effect on the acidic soil.

5.3 Remediation of heavy metal pollution: Biochar is an ideal material for remediation of organic and inorganic pollutants both in contaminated soil and water. This is because of its high specific surface area, micro-porosity and positively and negatively charged surface functional groups. The sorption of both organic and heavy metals pollutants is influenced by pH, specific surface area, particle size, time of exposure of pollutants and soil moisture. The inorganic ions or metals can be physically entrapped or chemically sorbed onto the biochar. The adsorptive competition occurs when multi-contaminants are adsorbed onto the biochar. The adsorption of Cu^{2+}, Cd^{2+}, $Pb^{2+}$and Ni^{2+}on the biochar. The alkalinity also causes some metals to precipitate from the solution on the surface of the biochar, therefore reducing the availability of theses metals to the plants. In addition to this, the heavy metals are less mobile in the soil with neutral pH or above, since the biochar increases soil pH, which in turn will decrease the mobility of the metals in the soil. Soil pH significantly affects the adsorption of Cu^{2+} and Zn^{2+} on the biochar.

5.4 Carbon sequestration: Carbon storing capacity of the soil is three times more than that of the carbon existing in the atmosphere. The storing capacity can be further increased if the rate of carbon inputs exceeds the rate of mineral decomposition. Carbon sequestration is the process of storing carbon in soil organic matter and thus removing it from the atmosphere. The biochar potential to sequester the carbon in the soil has received considerable attention in recent years and plays a big role in the climate smart agriculture. Approximately 70–80 per cent of the carbon present in the biomass gets trapped in the structure of the biochar that is stable in nature compared to the biomass, which on degradation releases the carbon back to the atmosphere.

5.5 Mitigation of climate change: Over the last few decades, the concentration of CO_2 and other GHGs has increased at a rapid rate, mainly because of industrialization and unsustainable development. This increase in CO_2 and GHGs generally leads to global warming, which needs to be controlled. So, it has become imperative to mitigate GHG emission by eco-friendly methods and biochar

ISSN (E): 2583 – 0821

can be one of them. Biochar application to soils may increase carbon sequestration and it leads to increase in recalcitrant carbon pool. But the effect of biochar application on GHG flux is variable among many studies. So, there is uncertainty in carbon sequestration by using biochar in the flux. biochar application significantly increased CO_2 flux by 22.14%, decreased N_2O flux by 30.92% and did not affect the CH_4 flux. Therefore, according to them biochar application may significantly contribute to increase in global warming potential of total soil GHG flux due to high stimulation of CO_2 flux. However, the CO_2 flux from the soil is suppressed when biochar is added to fertilized soils, indicating that the CO_2 emission will be suppressed from the agricultural soils where fertilizers (particularly N) are added to the soils. The soil GHG flux varied with source of feedstock, soil texture and the pyrolysis temperature of biochar. To a limiting extent, soil and biochar pH, biochar application rate and latitude also influence the soil GHG flux.

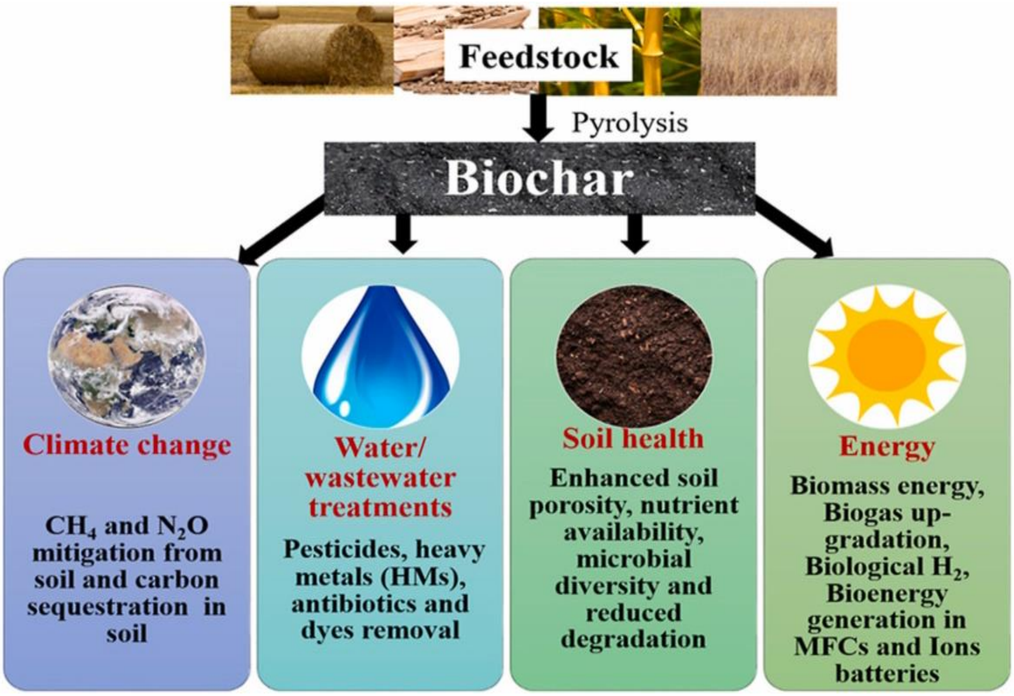

Fig 3 Environmental Benefits of Biochar Application (Malyan *et. al.*2019)

CONCLUSION

The key biochar production method, pyrolysis, modifies nutrient content in crop residues, impacting soil fertility through thermal degradation and volatile nutrient losses. Biochar, when integrated into soil, improves its physical, chemical, and biological properties, boasting a high cation exchange capacity that retains nutrients, enhancing crop productivity. Research focuses on biochar's role in acidic soil improvement, heavy metal remediation, and carbon sequestration, with potential applications in conservation agriculture. Proper dosage optimization based on soil characteristics is crucial, and despite its inert nature, biochar serves as an effective soil amendment, fostering microbial activity. Additionally, biochar proves useful as an adsorbent, mitigating pollution in sewage water, large kilns, and contaminated sites. In summary, biochar, when used appropriately, contributes to long-term soil productivity enhancement, carbon sequestration, and pollution reduction.