AGRICULTURE & ENVIRONMENT
E-NEWSLETTER
agrinenv.com

Article ID: AEN-2021-02-06-017

Biochar: A Carbon Enricher to Boost Soil Productivity

Navya Vishweshwar Bhat[1*] and Jayanth S[2]

[1]Department of Fruit Science and Horticulture Technology, OUAT, Bhubaneswar, 751 003 India.
[2]Department of Vegetable Science, ASPEE College of Horticulrure and Forestry, NAU, Navsari
[*]*Corresponding author. E-mail: navya.vbhat@gmail.com*

Depletion in soil organic matter and soil nutrients, decline in agricultural productivity and changes in climate due to anthropogenic activities are posing great threats to the sustainability of agricultural production (Parry 2007, Pender 2009). Agricultural activities and soils release greenhouse gases, and additional emissions occur in the conversion of land from other uses. Unlike natural lands, active management offers the possibility to increase terrestrial stores of carbon in various forms in soil. Biochar sequester carbon as thermally stabilized (charred) biomass using existing organic resources. Biochar can be defined as a carbon richer product obtained when biomass such as wood, manure or leaves is heated at relatively low temperature (700^{o}C) in a closed container with little or no available air. In more technical terms, biochar is produced by thermal decomposition of organic material under limited supply of oxygen. The mechanisms of biochar function in soil, which appear to be sensitive to the conditions prevailing during its formation or manufacture, are also affected by the material from which it is produced. Application of biochar to soil as a technique to enhance crop productivity and soil fertility has emerged in recent years. It has the ability to aid in coping up with the greenhouse gases (GHG) and is helpful for carbon sequestration.

Agricultural benefits of Biochar:

Improving soil for crop production

Due to rapid depletion of agricultural areas and soil quality by means of ever increasing population and excessive addition of chemical fertilizers, a rehabilitated attention is a need of the hour to maintain sustainable approaches in agricultural crop production. Biochar is the solid, carbon rich material obtained by pyrolysis using different biomasses. The application of biochar could adjust the soil structure (surface area, pore size and distribution etc.). Improve the soil physicochemical properties (pH, cation exchange capacity, water retention capacity etc.) because biochar is rich in organic carbon content, which makes the soil more fertile and acts as a carbon sequestration agent over a long term. Good healthy soil should include a wide and balanced variety of life forms, including bacteria, fungi, protozoa, nematodes, arthropods and earthworms. Biochar has been reported to increase the microbial respiration of the soil by creating space for soil microbes and in turn the soil biodiversity and soil density increased. Biochar also served as a habitat for extra-radical fungal hyphae that sporulated in micropores due to lower competition from saprophytes and therefore served as an inoculum for arbascular mycorrhizal fungi.

Nutrient availability in soil

Biochar itself is considered a source nutrient and can alter the soil nutrient pools and availability. Biochar applied up to 10 cm depth of soil may decrease the denitrification potential and lower N_2O emission, greatly controlling leaching of mobile nutrients such as potassium, thus improving water use efficiency, nutrient availability and plant growth. The heterogeneous composition of biochar means that its surface can exhibit hydrophilic, hydrophobic, acidic, and basic properties, all of which contribute to the ability of the biochar to adsorb solutes from soil solution, thus affecting nutrient retention. On the one hand, biochar can increase nutrient retention by the adsorption process. In addition, it also can be used to adsorb various contaminants (heavy metals,

organic matters), modify the habit and function of microorganism and mitigate climate problem by changing the bioavailability of elements (C, N, K etc.) in soil.

Increase in the production of crop

Increase in the crop production happens because of the increase in soil fertility due to biochar, the growth of seeds increased and crop yield also increased significantly as compared to the soils not having biochar. Biochar soil amendment improves crop productivity mainly by increasing nutrient use efficiency and water holding capacity. However, improvements to crop production are often recorded in highly degraded and nutrient poor soils, while its application to fertile and healthy soils does not always increase crop yield. The biochar amendments induced resistance in plants against diseases by inducing systemic resistance. This resistance is either derived from large microbial populations like *Trichoderma spp*. or from phytotoxic compounds (e.g., ethylene and propylene glycol) in biochar-treated soils.

Environmental benefits:

Carbon sequestration, rehabilitation of degraded lands, reduced GHG emissions, adsorption of contaminants to offset streams, and groundwater pollution are among the environment related benefits linked with biochar (Lehmann *et al.* 2006; Beesley *et al.* 2010; Mohan *et al.* 2014). Carbon sequestration is the long term storage of CO_2 or other forms of carbon to mitigate or defer global warming. Increased soil C stock is the most pronounced effect of biochar soil application. The mean residence time of biochar in soils is estimated to be more than 1000 years. The long-lasting stability of biochar is the basic foundation when considering it as a C sequestration technique. Even when subjected to severe weathering conditions in a tropical climate, biochar was highly resistant to chemical degradation with no obvious decline in stocks. Biochar acts as a super sorbent with the ability to remove organic and inorganic contaminants from the soil as well as water because of its physiochemical properties.

Conclusion:

The long-term effects of biochar on soil functions and its fate in different soil types require immediate attention. Biochar may change the soil biological community composition and abundance. Integrated nutrient and pesticide management strategies are necessary in order to increase sustainable agricultural productivity and to conserve natural resources. In agriculture development, fertilizers and pesticides are important plant nutritional and protective agents for boosting crop production. However, the use efficiency of fertilizers in crop systems is usually very low. Moreover, the indiscriminate use of pesticides can cause severe environmental contamination. Amending soil with biochar to enhance plant nutrient uptake and pesticide degradation may be a suitable way to ameliorate these problems.

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