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# BIOCHAR FOR SOIL HEALTH ENHANCEMENT AND CROP PRODUCTIVITY IMPROVEMENT

**Popular Article**

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**ABSTRACT**

**Most of the crop residues, agro-industrial wastes and agricultural by-products create management problems to farmers in agronomic practices in fields. If these materials, will convert into biochar by pyrolysis technique, then it may be a significant opportunity for maintaining soil health as well as crop productivity. Biochar positively affect the physical, chemical and biological properties of soil, but, effects were varied from soil to soil. Physical and chemical characteristics of biochar depend upon types of feed stocks and pyrolysis conditions. Biochar production on a large scale is a major constraint in adoption of this technology, because of non- existence of any sustainable technology. There is need of future research for promoting the use of biochar on large scale. It is essential to make low-cost and eco-friendly production unit of biochar for farmers to exploit potential of biochar.**

## Introduction

Crop residues generally creates management problems to the farmers at farm as well as in land in different manners, such as difficulty in field preparation, irrigation, making bunds and disposing in different places. Abundantly available crop residues are straws of paddy, wheat, millet, sorghum, maize, pigeon pea, castor, mustard, stover and cobs of maize, cotton and jute sticks, sugarcane trash, fibrous materials, roots and branches of many other crops. In the same way, agricultural by-product and agro-industrial residues are existing in huge quantities like rice husk, mustard husk, coffee husk, shell of groundnut, cotton waste, shell of coconut, coir pith, shell of tamarind, cassava peels, sugarcane bagasse, tea waste, casuarina leaf litter, silk cotton shell, oil palm fibre and shells, cashew nut shell, coconut shell and coir pith etc.

This large extent of biomass can be efficiently used for maintaining the soil health and soil quality, by converting into a soil amendment, by pyrolysis process. Burning of residues usually provides a rapid mode to clear the farm land for further field preparation and planting. Nevertheless, it leads to release of greenhouse gas emissions. In this perspective, biochar, a pyrolysis product of plant biomass creates a significant opportunity to convert large scale agricultural waste into a valuable amendment of soil. Use of biochar in agricultural system is a viable option that can enhance natural rate of carbon sequestration in the soil, reduce farm waste and improve the soil quality and crop productivity. Biochar is a carbon rich solid substance, made by pyrolysis of biomass. It would be used for long term soil carbon sequestration as well as soil health enhancement by storing atmospheric carbon. Biochar occupied condensed aromatic structure which is responsible for its resistance against decomposition and make carbon stable in soils for long time, and can be a suitable approach to lock carbon in the soil. Biochar is a new word for many in India, but the technology of its preparation is traditional one in many parts of the world. Several years ago, heating or carbonizing timber for the use of manufacturing biochar has been practiced (Emrich, 1985). There are various techniques of biochar production, but, all of them involves heating of biomass in absence of oxygen to remove volatile gases, and retained carbon behind.

**Characteristics of biochar**

Characterization of biochar is the first stage to recognize the mechanism of action. The biochar properties are controlled by its physical and chemical constituents. The types of the feedstock, pyrolysis time and pyrolysis temperature may affect the quality and potential use of biochar. The value of biochar is determined by its physical and chemical characteristics, even though some times, the correlation between properties of biochar to these applications is not well understood. Characterization of biochar, before its application in soil is helpful in recognizing the mechanisms between biochar and soil.


Fig 1. Rice husk biochar

**Effect of biochar on soil health and soil fertility**

Application of biochar in soil is a sustainable technology to improve weathered or degraded soil. Consequence of biochar application on soil health and fertility has been varied but usually helpful and described under following subheadings.

**Effect of biochar on soil physical properties**

Low density and porous structure of biochar helps to reduce the bulk density of soil in long term application. Biochar improves water holding capacity of sandy soil, although different biochar materials differ in their ability to positively impact soil water retention. Intensive agronomic practices lead to breakdown of the soil aggregates leading to soil erosion, and biochar has capacity to interact with minerals and "resident' organic matter of soils and increases the soil aggregates stability, which reduce the soil erosion. Biochar also have capacity to provide dark colour to soil, and darker soil has a lower albedo, which absorb more radiation.

**Effect of biochar on chemical properties of soil**

Application of biochar can augment plant growth by improving soil chemical properties, such as availability of nutrients, retention of nutrient in soil and increase the cation exchange capacity, all these properties help for improving crop productivity. In such types of soils, where the soil's pH is low, biochar can be a useful soil amendment which improves the availability of basic cations. The pH of biochar generally alkaline in nature and in most of the cases above 9, and biochar sometime has liming value to the some extent. Biochar improves the availability of nutrient in soil by addition of nutrients and retention of nutrients. Biochar is a good source of basic cations such as calcium, magnesium, and potassium. Since, biochar is a highly porous and has a large surface area, which helps to increase the cation exchange capacity (CEC) of soil in long term. Biochar reduces the leaching of nutrients through the soil profile. Reduction in leaching of basic cations was attributed to increasing CEC, when biochar had been applied.

**Effect on biological properties of soils**

Soil microbes makes colony and easily grow in porous surface of the biochar, where are, their predators cannot access them. Moreover, the reason behind it, the surfaces of biochar sorbs organic substances as well as inorganic nutrients which might be provided ideal environments for soil microbes. Although the size of pores varies from biochar to biochar, it is generally sufficient for a most of the soil microorganisms to colonize. Biochar application to soil has positive impacts on mycorrhizal abundance as well as mycorrhizal activity. Some researcher's assumed that there are four mechanisms in which biochar could enhance plant-mycorrhizal interactions and mycorrhizae abundance. The first is, improvement in physical and chemical properties of soil, including enhancement in nutrients availability. Secondly, biochar can alter the activity of other soil microorganism, which has ultimate influence on mycorrhizae. Next, biochar might be altering the signalling between host plants and mycorrhizae, or it may have capacity to detoxify allelochemicals. Changes in the abundance of these compounds can significantly impact the growth of mycorrhizal fungi and the improvement of plant-microbe symbioses, but still, this mechanism is not clear. Lastly, biochar act as a shelter for mycorrhiza.

**Effect on crop productivity**

The effect of biochar on crop productivity has been observed to be different, but is usually positive. Majority of the experiments were carried out in acidic tropical soils where, large yield improvements were obtained. In India some researchers conducted experiment on crop productivity with biochar application and gave some findings. Purakayastha (2010) reported that addition of wheat straw biochar @ 1.9 t $ha^{-1}$ along with recommended doses of fertilizers (NPK:: 180:80:80) significantly enhanced the maize yield in inceptisols, and this treatment was superior over crop residue incorporation. Report of CRIDA (2012) showed the cotton stalk biochar addition @ 3 t $ha^{-1}$ supplements with NPK in alternate year gave the highest pigeon pea grain yield. On the other hand application of castor stalk biochar @ 6 t $ha^{-1}$ along with NPK gave marginally greater yield over other treatments. Sole application of biochar has no immediate significant effect on growth and total dry matter yield of rice, but, when biochar applied along with PGPR, it significantly improved growth and total dry matter yield of rice in pot using alluvial soil of Varanasi (Singh *et al,* 2015).

**Constraints in use of biochar for soil health enhancement**

Production of biochar is a major constraint in use of biochar, because, there are lack of chief and eco-friendly techniques in which biochar produced on a large scale, and also during biochar preparation, lack of mechanism for storing volatile oil and gasses. On the other hand, numerous other applications for diverse types of biomass have been used in the past, are in current demand, and may become popular in the future. The biomass materials are used as fodder, mulching, compost making, fuel purpose, thatching for rural homes and also some biomass immediately burned by farmers for preparation of field. Other constraints in biochar production methods arise because of emissions of $CH_4$, $N_2O$, soot or volatile organic compounds combined with low biochar yields of biochar. Similarly, the biochar has long term impacts on soil quality and crop productivity, but farmers generally want quick response after application so this is a one of the basic constraints. But, to encourage the farmers for use of biochar as a soil amendment, research, development and demonstration on preparation of biochar and its application to soil is very important.

**Future research needs for promoting use of biochar**

Very few information are available on use of biochar for agriculture in India. Globally biochar is used as a soil amendment on large scale in agriculture because they have lot of information on research and advance techniques for specific types of biochar production. There is a need of statistics, how much non-feed biomass resources in India, which do not have any judicious use and also development of eco-friendly, chief and efficient thermo-chemical conversion technology for preparation of biochar. Further, need of research in some important areas of biochar use in agriculture required.

- Development of proven technology for production of biochar on large-scale at a small farm.
- What will be the long term impact of different types of biochar on soil microorganisms, whether they benefited or harmed, and what are the mechanisms?
- Biochar have rich source of basic cations, so what is the mechanism of nutrients release/availability?
- What will be the effect of long-term application of biochar on soil quality and agronomic productivity?
- What should be the optimum rate of biochar addition to different types of soil?

- Generally biochar has a high pH, so what will be the long term effect of biochar on acid soil as well as alkaline soil?

**Conclusion**

Generally most of the crop residues create problem in managing the crops in fields. These residues do not have any judicious use. If these residues are converted into biochar by suitable technology, then it might play very important role for enhancing the status of soil health. Currently, several institutes are doing research on biochar preparation from different types of biomass and its effect on soil quality and crop productivity. Several results revealed that addition of biochar to soil improved soil health and crop productivity. Nevertheless, to encourage the use of biochar as a soil amendment, some policy on biochar production and application is very vital. It is essential to construct low-cost and eco-friendly biochar production unit for small and marginal farmers.

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