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Biochar - The New Black Gold

Sainath Nagula* and A. V. Ramanjaneyulu

Professor Jayashankar Telangana State Agricultural University, Agricultural Research Station, Tornala, Telangana (502 114), India

Abstract

Conventionally, farmers, after meeting the cattle feed requirements, have been using the crop residues as either cattle feed, fire wood or burning, which is finally leading to environmental pollution, loss of valuable nutrients, organic carbon and increase in greenhouse gas emission. Though several options are available to utilize these residues by converting into compost, vermicompost, of late, scientists have come out with a permanent solution *i.e.,* conversion of this waste into wealth in the form of biochar. It is produced through thermo-chemical conversion of plant biomass at high temperature in the absence of oxygen. It improves soil fertility and productivity through improvement of soil physical and chemical properties. It reduces heavy metal contamination in the soils. Biochar helps in carbon sequestration and reducing greenhouse gas emission, thus, minimizes the ill effects of global climate change. Its addition has the potential to double the crops yields thus improves farm income.

Introduction

Agricultural waste is usually handled as a liability often, because the means to transform it into an asset is lacking. These residues are either partially utilized or un-utilized due to various reasons. Among the cereal residues, rice and wheat straws are the dominant and the easiest way to clear the field is burning these in the field itself handling large volume of residues is a difficult task. By realizing those problems, some of the researchers produced more resistant organic matter such as biochar. Biochar has great importance in improving soil fertility and it could act as a soil amendment to increase crop yield and plant growth by supplying and retaining nutrients than other organic matter such as leaf litter, compost or manure. Conversion of biowaste to biochar is a potential tool for carbon sequestration and reducing greenhouse gases emission.

Figure 1: Biochar

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Corresponding Author

Sainath Nagula

e-mail: sainathnagula134@gmail.com

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E-mail: *bioticapublications@gmail.com*

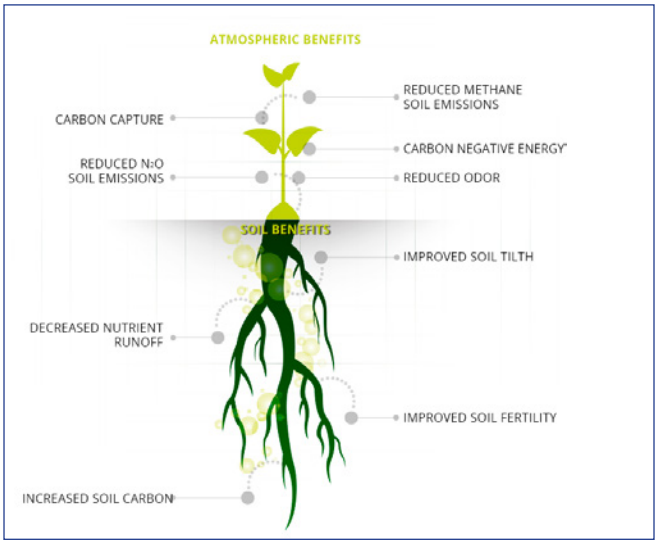

Figure 2: Biochar Benefits

What is Biochar?

Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process at high temperatures with little or no oxygen. 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. Because of its aromatic structure dominated by aromatic carbon, biochar has been found to be biochemically recalcitrant compared to uncharred, parent organic matter and have considerable potential to enhance the long term soil carbon pool and a net carbon withdrawal from the atmosphere of 20%.

Biochar Production

Biochar is produced by heating biomass in the total or partial absence of oxygen. Pyrolysis is the most common technology employed to produce biochar, and also occurs in the early stages of the combustion and gasification processes. Besides biochar, bio-oil and gas can be collected from modern pyrolysers. These could be refined to a range of chemicals and/or used as sources of renewable energy if derived from sustainably produced biomass.

Soil Quality and Fertility Improvement

The central quality of biochar that makes it attractive as a soil amendment is its highly porous structure which is potentially responsible for increased soil surface area and improved water retention. Because of its aromatic structure dominated by aromatic carbon, it has been found to be biochemically recalcitrant compared to uncharred, parent organic matter and thus can have enhance the long-term soil carbon pool.

Biochar application to soil leads to several interactions mainly with soil matrix, soil microbes and plant roots. The types and rates of interactions depend on different factors like composition of biomass as well as biochar, methods of biochar preparation, physical aspect of biochar and soil environmental condition mainly soil temperature and moisture. Application of biochar to in-fertile soils decreases soil bulk density, increases total pore volume and water holding capacity. Presence of biochar in the soil mixture influences the texture, structure, porosity and consistency through changing the bulk surface area, pore-size distribution, particle-size distribution, density and packing. Thus, biochar's effect on soil physical properties may have a direct impact upon plant growth because the penetration depth and availability of air and water within the root zone is determined largely by the physical make-up of soil horizons.

Table 1: Effect of biochar on different soil properties

S. No.	Particular	Impact
1	Cation exchange capacity	50 % increase
2	Bulk density	13 % decrease
3	Water holding capacity	5.9 to 25.5%increase
4	Total pore volume	16%increase
5	Specific surface area	15 % increase
6	Fertilizer use efficiency	10 to 30 % increase
7	Liming agent	01point pH increase
8	Methane emission	100 % decrease
9	Nitrous oxide emissions	50 % decrease
10	Mycorrhizal fungi	40 % increase
11	Biological nitrogen fixation	50 to 72 % increase

Remediation

Carbonaceous materials such as char and activated carbon have received considerable attention in recent years as soil amendment for both sequestering heavy metal contaminants and releasing essential nutrients like sulphur. Information is currently lacking in how aging impacts the integrity of biochar as soil amendment for both agricultural and environmental remediation purposes. Biochar has a relatively structured carbon matrix with a medium-to high surface area, suggesting that it may act as a surface sorbent which is similar in some aspects to AC (activated carbon).

Crop Productivity

The application of biochar to soil has been shown to improve crop yields which could be due to direct or indirect effects. The direct effect is explained by the

fact that biochar being concentrated during pyrolysis contains higher amount of nutrients than the biomass from which they are prepared. The indirect effect is due to improvement in soil physical, chemical and biological properties due to biochar application. Several workers have reported that biochar applications to soils have shown positive responses for net primary crop production, grain yield and dry matter. Several workers have reported that biochar applications to soils have shown positive responses for net primary crop production, grain yield and dry matter.

Figure 3: Sequestering biochar in soil, which makes soil darker in colour is a robust way to store carbon

Biochar for Greenhouse Gas Mitigation

As one major goal of biochar soil amendment is to sequester carbon in order to mitigate climate change, numerous studies addressed the microbial response to biochar addition in terms of emissions of the greenhouse gases N_2O, CO_2 and CH_4 from soil. In comparison to burning, controlled carbonization converts even larger quantities of biomass organic matter into stable C pools. The conversion of biomass carbon to biochar leads to sequestration of about 50% of the initial carbon compared to the low amounts retained after burning (3%) and biological decomposition. Biochar is added sustainably; per annually sequester an amount of C equal to 12% the current anthropogenic CO_2 emissions. It was reported to reduce N_2O emission could be due to inhibition of either stage of nitrification and/or inhibition of denitrification, or promotion of the reduction of N_2O, and these impacts could occur simultaneously in a soil.

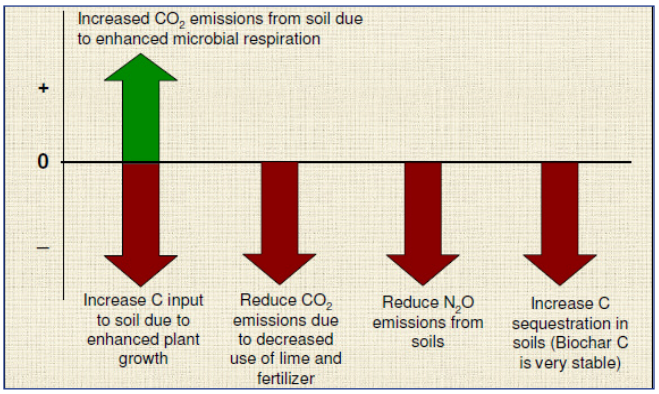

Figure 4: Net impact of biochar applications in soil on greenhouse gas emissions

Conclusion

Conversion of biomass into biochar eliminates the need for burning crop residues thereby environmental pollution. Its application brings about significant improvement in overall soil condition thus soil health. It will become a good source of nutrition in organic farming, if the biochar production technology is upscaled and outscaled. Further research is required to identify most suitable location specific and economical feed stock across all agro-climatic zones in India. As biochar production and utilization is at infancy stage in the country, efforts must be made to improve the awareness of stake holders regarding its' usage and associated benefits.

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