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Effect of biochar to improve soil health, reduced carbon emission and mitigation of greenhouse gaseous-A review

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Abstract
Biochar is a carbon-rich co product resulting from pyrolyzing biomass. When applied to the soil it resists decomposition, effectively sequestering the applied carbon and mitigating anthropogenic CO_2 emissions. Biochar is thermo-chemical degradation of biomass under anaerobic or oxygen-limited conditions. Due to its properties related to surface area and porosity, bulk density, nutrient content, stability, cation exchange capacity (CEC), pH value, and carbon content, biochar has the potential to improve physical as well as chemical soil properties and thus improve crop productivity and contribute to carbon sequestration. We review here effect of biochar to improve soil health, reduced carbon emission and mitigation of greenhouse gaseous.

Keywords: Biochar, Soil fertility, Carbon sequestration and Greenhouse gaseous

Introduction
Soil organic matter (SOM) improves soil fertility and productivity by providing nutrients through mineralization, nutrient cycling, and water holding capacity and acts as habitat for soil micro fauna and flora (Jakhar *et al*., 2017; Kakraliya *et al*., 2017) [5, 10]. Biochar is a balanced form of charcoal produced from heating natural organic materials (crop residues, wood material, manures and other agricultural waste) in a high temperature and low oxygen. The efficiency of carbon conversion of biomass to biochar is highly dependent on the type of feedstock, but is not significantly affected by the pyrolysis temperature (within 350-500°C common for pyrolysis). Pyrolysis is the thermal decomposition of biomass i.e. biomass is conversed to char, combined gas (mixture of H_2, CO, CH_4 and CO_2) and bio-oil with heat energy in absence of O_2. Production of biochar generally releases more energy than it consumes, depending on the moisture content of the feedstock and temperature of combustion. Heat, oil, and gas that are released can be recovered for other uses, including the production of electricity and bio-fuel production (Atkinson *et al*., 2010) [1].

Effect of biochar to improve soil health-
The term 'biochar' refers to black carbon formed by the pyrolysis of biomass i.e. by heating biomass in an oxygen-free or low oxygen environment such that it does not (or only partially) combusts (Bajiya *et al.*, 2017) [2]. Biochar has high concentrations of organic carbon, high porosity and surface area improvement in soil physical properties including soil structure, aggregation and water holding capacity would be expected following incorporation into soils. Compared without application of the biochar, biochar addition significantly enhanced the formation of macro-aggregates and slightly increased saturated hydraulic conductivities of the soils. Attributable to the soil structure change, saturated water contents increased and residual water contents decreased with the biochar amendment. These changes with biochar addition greatly affected the shape of soil water retention functions. The incorporation of biochar into the soil may modify the physical and hydraulic properties of the porous medium, such as bulk density, water retention, hydraulic conductivity, and porosity and penetration resistance. The effective maintenance of biochar in degraded soils can help preserve soil fertility and reduce erosion susceptibility by promoting soil aggregation stability, and improving hydraulic conductivity and water retention and holding capacity. Organic wastes, such as livestock manures, plant manures, sewage sludge, crop residues and composts are converted to biochars and then applied to soils as an amendment. Many studies have discussed the influences of biochar is a useful resource to improve the physicochemical properties of soil, properly maintain SOM levels, increase input use efficiency and increase crop productivity, particularly for long-term cultivated soils in warm and humid climate. The increased nutrient content of

soil following biochar application also contributed to the increased yields of cereals. Uptake of nitrogen, phosphorous and potassium were also increase by addition of biochar (Fischer, D. and Glaser, B., 2012) [3]. Soil texture is an important physical property related to soil aggregation and hydraulic properties, biochar addition in soils with different textures should affect the soil hydraulic properties and soil aggregation differently. The application of biochar also decreased maize salt stress. Since Na is the main ion causing salt stress in plants, biochar application was thought to decrease Na concentration in maize tissue (Kim, *et al*, 2015) [11]. The application of biochar to soils might be a practical method to aid in the long-term maintenance of the soil active as well as passive carbon pool and soil fertility. In addition to soil pH, the CEC significantly increased from 7.41 to 9.26 (2.5% biochar) and 10.8 cmol (+) kg^{-1}(5% biochar) with the application of biochar. The biochar-amended soils also showed an increase in the CEC with incubation time. The soil pH was proportional to the percentage of biochar added. The exchangeable K, Ca, and Mg contents also significantly increased in the biochar-amended soil compared with the control (Jien and Wang, 2013) [9]. Other changes in the bulk density, the biochar-amended soils exhibited significantly higher total porosities (more than 50%) than the unamended controls (41%) after 105 days incubation (Jien and Wang, 2013) [9]. According to studies, the higher MBC contents were always found in the biochar amended soils at 0 days, 63 days and 105 days, indicating that biochar application could effectively increase microbial activity in the soils (Jien and Wang, 2013) [9]. These increased activities of soil organisms including bacteria, fungi and actinomycetes make up the soil foodweb, which carries out biological nutrient cycling (Meena *et al*., 2016) [14]. Many research studied that on the effects of biochar properties at the level of primary decomposers (bacteria and fungi). Other functional groups, including secondary decomposers, predators, and soil animals, also play important roles in nutrient and energy cycling. An interesting result in experiment was that biochar application at 10 % resulted in an increased aboveground biomass and lower root biomass, indicating that improved soil resources required fewer roots to sustain aboveground biomass production (Yang *et al*., 2015) [18].

Biochar effects on environmental reclamation

In a number of studies, it has been shown that biochar has the potentials to bind both organic and inorganic pollutants including pesticides from environment via chelate formation. Moreover, if biochar is produced from waste biomass, environmental pollution can be reduced considerably. As compared to biomass burning, the release of smoke and gases is low in pyrolysis process. So, it could be a good technology for us, if we could utilize our municipal waste for biochar production.

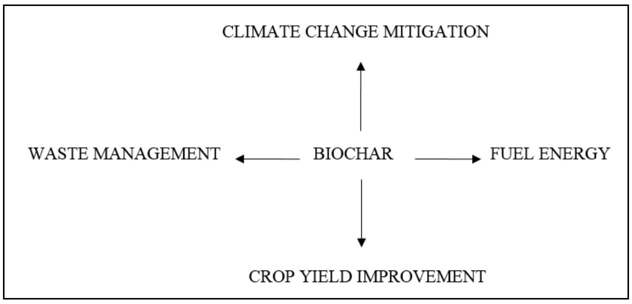

Fig 1: Benefits of biochar technology

Effect of biochar to reduced carbon emission and mitigation of greenhouse gaseous-Agricultural production is now suffering from land degradation and soil erosion due to poor management strategies and practices; continuous cultivation and which causes a decrease in soil fertility and depletes soil biodiversity and increase atmospheric Greenhouse gasses which result to higher temperatures (Global warming). Biochar could serve as one of the tools in addressing these problems of agriculture and Global warming. After biochar amendment, reduced greenhouse gas such nitrous oxide, carbon dioxide and methane emission from soil has also been reported in a number of scientific studies. Therefore, biochar application to soil is a potential tool for climate change mitigation. Biochar has a very low bulk density and particle density, hence for the volume it occupies within the soil and its low mass due to its porous nature. Another major benefit associated with the use of biochar as a soil amendment is its ability to sequester carbon from the atmosphere and transfer it into the soil thereby mitigating climate change. The aim of this study was to evaluate the effect of biochar on physical and chemical properties of the soil and amount of carbon that can be stored in the soil and reduced carbon emission (Ndor *et al*., 2014). Composting of biochar combined the high C sequestration of biochar (stable C-rich but N-poor material) and the fertilization potential of compost (labile organic matter rich in mineralizable nutrients). Adoption of integrated nutrient management involving Inorganic fertilizers and bio-fertilizers application improved the soil health (Jangir *et al.*, 2017c) [6].

A recent study incorporating a set of aggregatesustainability criteria estimates the ‘biochar to mitigateclimate change as a maximum of 1.8 Gt of CO_2 equivalents (incorporating also methane and nitrousoxide) per year without endangering food security, habitat or soil conservation. This is equivalent to 12% of current anthropogenic CO_2 emissionsannually (Woolf *et al*., 2010) [17]. 1 Gt C/year has been deemed a cut-offpoint for approaches to greenhouse gas abatementto be taken seriously. Also, the soil release of methane (CH_4), which has a 25 times greater global warming potential than CO_2, can be reduced. In 2004-05, CH_4 constituted around 14% of global GHG emissions, counted in CO_2 equivalents, and while some soils, especially under anaerobic conditions emit CH_4 globally, soils consume 5% of the annual load of CH_4 to the atmosphere, and are therefore a net sink. Biochar application to soils could increase this sink (Lehmann, 2009) [13]. The soil release of nitrous oxide, which has a 310 times greater global warming potential than CO_2, can be reduced. Under anaerobic conditions N_2O is emitted from soil through denitrification (Meena *et al*., 2017) [15]. Biochar is reported to reduce N_2O emission could be due to inhibition of denitrification, or promotion of the reduction of N_2O, and these impacts could occur simultaneously in a soil. Increased soil aeration from biochar addition reduces denitrification and increases sink capacity for CH_4. Accounting for this effect makes a great difference to the overall analysis of how a biochar to soil strategy impacts on net greenhouse gas balance (Gaunt *et al*., 2008) [4]. The expectation for this effect relates to the general impact of biochar on retention of N in the soil in away that also enhances crop nutrition. It may be that, instead, biocharinhibits the process by sequestering dissolved mineral N.

The optimum application rate for biochar depends on the particular soil type and crop management. Biochar can also be applied incrementally and incorporated with fertilizer or compost applications. Judicious combination of biochar, fertilizer and manures through improve the physical, chemical as well as biological properties of soil. biochar can be applied to (1) applied as the soil surface and, properly covered with other organic materials, (2) applied mixed with compost, manure or mulch, or (3) applied as a liquid slurry if finely mixture.

Biochar and bioenergy generation

Biochar is, in fact, bioenergy by-product. When biomass is paralysed, the biomass produces different gas (mixture of H_2, CO and CO_2) and huge amount of heat which can be utilized as power for cooking and electricity generation. If pyrolysis is conducted at high temperature (>700 °C), bio-oil can be collected. Industrial bioenergy generation with simultaneous biochar production is growing quickly in the developed countries of the world.

Prospect of biochar technology in India

As a technology, biochar could be a very promising technology for India. *First*, we have huge amount biomass waste, for instance, Delhi, Jaipur and Kolkata cities produces more than 2000 tons of waste per day. We also have poultry litter and huge amount of solid waste like apparel industry by-products. Furthermore, we also have wood biomass which we use for cocking purposes. This biomass can be used for dual purposes both for power generation (cooking and electricity) and biochar production. *Second*, the percentage of organic matter, the life of soil, is alarmingly low and decreasing for our intensive crop production practices. Application of biochar can solve this problem as it retains in soil for many years and can serve soil functions (biological activity, water flow, buffering, and nutrient cycling). *Third*, biochar increases fertilizer use efficiency especially the N by reducing leaching. So, fertilizer costs for urea might be reduced considerably if we can adopt biochar technology. In addition, it has been shown that P bioavailability increases with biochar amendment in highly weathered soils. So, it could be a very good soil amender for our red soils. Nevertheless, biochar can also be used as organic and inorganic pollutant absorber which through free from pollution. Combined inoculation of N2 fixers, biochar and PSB benefit the plant than either group of organisms alone and may have added advantage in the degraded agro ecosystem (Jangir *et al*., 2017 a,b) [7, 8]. Therefore, we might use biochar to treat industrial effluent which otherwise pollute our rivers. This is very simple and easy technology which can be used by anybody and in anywhere.

Conclusions

Composted biochar addition to macro-porocity substrates led to increased plant growth. This effect was the higher, the more composted biochar was added and the higher the biochar contribution to the applied mixture was. This could be explained by an increase in soil TOC content and by providing plant-available and mineralizable nutrients. Composting of biochar combined the high C sequestration of biochar and the fertilization potential of compost (labile organic matter rich in mineralizable nutrients). Our study clearly revealed that plant growth and soil fertility was higher the more composted biochar was added. In addition, this effect was higher, the higher the biochar amount was, indicating an optimum composition with respect to labile/stable organic matter and nutrient composition.

We suggest that further studies are needed to assess the complete effect of biochar application on physical, chemical and soil nutrients using efficiency, especially for N fertilizer use efficiency and relative N losses in the field.

References

1. Atkinson C, Fitzgerald J, Hipps N. Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils: a review. Plant Soil. 2010; 337(1):1-18.
2. Bajiya R, Lakhran H, Kumar S, Seema. Biochar for enhancing agricultural sustainability under climate change. International Journal of Current Microbiology and Applied Sciences. 2017; 6(2):1876-1883. http://dx.doi.org/10.20546/ijcmas.2017.602.212
3. Fischer D, Glaser B. Synergisms between compost and biochar for sustainable soil amelioration. In: Sunil K, Bharti A (eds) Management of organic waste. In Tech, Rijeka, Croatia, 2012, 167-198.
4. Gaunt J, Lehmann J. Energy balance and emissions associated with biochar sequestration and pyrolysis bioenergy production, Environ. Sci. Technol. 2008; 42:4152-8.
5. Jakhar SR, Kumar S, Jangir CK, Meena RS. The role of mycorrhizal relationship in sustainable manner towards plant growth and soil fertility. Indian Journal of Agriculture and Allied Sciences. 2017; **3**(4):19-24.
6. Jangir CK, Singh DP. Effect of Fertility Levels and Bio-fertilizers on Yield and Micro Nutrient Content and Uptake by Black gram (*Vigna mungo* L.). Research Journal of Agricultural Sciences. 2017c; 8(2):312-315.
7. Jangir CK, Singh DP, Choudhary J, Sharma J. Effect of fertility levels and biofertilizers on macro nutrient content and uptake by Black Gram (*Vigna Mungo* L.). Indian Journal of Ecology. 2017a; 44(4):142-145.
8. Jangir CK, Singh DP, Meena RH, Yadav M. Effect of Fertility Levels and Biofertilizers on Physical and Chemical Properties of Soil under Blackgram (*Vigna mungo* L.). Int. J. Curr. Microbiol. App. Sci. 2017b; 6(3):223-228.
9. Jien, Wang. Effects of biochar on soil properties and erosion potential in a highly weathered soil, Department of soil and water conservation, Catena. 2013; 110(225-233).
10. Kakraliya SK, Kumar N, Dahiya S, Kumar S, Yadav DD, Singh M. Effect of integrated nutrient management on growth dynamics and productivity trend of wheat (*Triticum aestivum* L.) under irrigated cropping system. Journal of Plant Development Sciences. 2017; 9(1):11-15.
11. Kim HS. Effect of biochar on reclaimed tidal land soil properties and maize (Zea mays L.) response. Chemosphere. 2015.
12. Kolb S. Understanding the mechanisms by which a manurebased charcoal product affects microbial biomass and activity. Dissertation, University of Wisconsin, 2007.
13. Lehmann J. Biochar for sustainable carbon sequestration and global soil enhancement, Testimony before the house select committee on energy independence and global warming, Washington, 2009.
14. Meena RS, Bohra JS, Singh SP, Meena VS, Verma JP, Verma SK *et al*. Towards the prime response of manure to enhance nutrient use efficiency and soil sustainability a current need: a book review. Journal of Cleaner Production. 2016; 112:1258-1260.
15. Meena RS, Gogoi N, Kumar S. Alarming issues on agricultural crop production and environmental stresses.

Journal of Cleaner Production. 2017; 142:3357-3359.

16. Ndor SM, Asadu CLA. Effect of Biochar on Soil Properties and Organic Carbon Sink in Degraded Soil of Southern Guinea Savanna Zone, Nigeria, International Journal of Plant & Soil Science. 2015; 4(3):252-258.
17. Woolf DJE, Alayne Street-Perrott F, Lehmann J, JosephS. Sustainable biochar to mitigate global climate change, Nature Communications. 2010; 1:56-58.
18. Yang L, Liao F, Huang M, Yang L, Li Y. Biochar improves sugarcane seedling root and soil properties under a pot experiment, Sugar tech. 2015.