Review Article: Effect of Biochar on Growth and Yield of Agricultural Produce

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Abstract— *Biochar is a boon for agricultural crops. Biochar is baked biomass that you can add to soil. It is a biomass that is thermally altered in the absence of oxygen, it is baked and not burned and flammable gasses are released (hydrogen, carbon dioxide). Heat transforms plant carbon (found in the cellulose and lignin) into fused aromatic carbon rings that are very stable. Biochar are made from different feedstocks at different physical and chemical properties. In carbon cycle almost all of the carbon returns to the air. Green plants remove carbon dioxide from the atmosphere via photosynthesis and convert it into biomass. Virtually all of that carbon is returned to the atmosphere when the plants die and decay, or immediately if the biomass is burned as a renewable substitute for the fossil fuels. While in the biochar cycle up to half of the carbon is sequestered, green plants removed and sequestered as biochar, while the other half is converted to renewable energy co-products before being returned to the atmosphere. Biochar retains soil moisture of the agricultural field. Worms loves biochar, it works best when composted with other organic matter before adding to garden soil. This allows life to colonize the biochar. Biochar composted with animal manure, it is inoculated with compost tea. Biochar composted with food waste and bokashi (anaerobic lactobacillus fermentation). Other activities include minerals, NPK, fungi, worm castings, fish emulsion, urea, etc. biochar can be added to soils to improve fertility. Reduces emissions from the biomass. Improves the water quality and quantity. Helps to improve the agricultural productivity. Valuable resource reduces the forest fires. Value added product for urban and rural agriculture and forest communities.*

Keywords— Biochar, Biomass, Green plants, Agricultural, Carbon, Sequestered.

I. INTRODUCTION

Biochar is considered by many scientists to the “black gold” for agriculture. It is the future of sustainable Agriculture. Green parts of solid waste are deposited inappropriately near the rural areas or cities, contributing to environmental impact. Biochar is a form of carbon, somewhat like charcoal, which can be made by heating wood with limited air. It differs from coke in that is very porous, having a very high surface can serve as a template for the growth of microorganisms such as bacteria and fungi, and can actively adsorb fertilizers. For this certain reason, it is valuable as an aid to farming and lumbering too. Initially, heat must be applied to start vaporization of volatile components. As the temperature increase, chemical reactions begin which liberate heat and form several products as volatile vapors, a portion of which can be condensed to form. Bio -oil is a liquid which can be burned or further refined, and biochar is a charcoal – like solid, of agricultural value. The relative amounts of these can be controlled by selecting heating rates and temperatures. The heat supplied by burning the vapors is more than sufficient to continue the process, so no net external energy is needed. Aggregation of soil is one of the crucial processes that facilitate carbon sequestration and maintain the soil fertility. The effect of biochar amendment on soil aggregation will remain inconclusive. Biochar application to soil is a carbon negative technology used to tackle climate change while sustainability improving soil fertility *(Lehmann et al., 2005).* There is a general agreement that the low degradability of biochar, like other types of black carbon, derives mainly from its specific chemistry, which is dominated by fused aromatic ring structures *(Haumaier and Zech, 1995); Glaser et al., 2000; Brodowski et al., 2005).* Despite its intrinsic low biodegradability, the introduction of biochar to soil does often result in an increase in carbon dioxide emissions in the short – term *(Sagrilo et al., 2014).* Among explanatory factors, the positive priming of biochar on the positive priming of biochar on the decomposition of native soil organic matter *(Maestrini et al., 2014)* and the abiotic release of carbon dioxide from the reaction of carbonates in the biochar after amendment to acidic soil *(Brunn et al., 2014*) were identified, nevertheless, the main source of the increase in carbon dioxide emissioins from a biochar amended soil seems to be the microbially mediated decomposition of labile biochar constituents (e.g., *Cross and Sohi, 2011; Hilscher and Knicker, 2011*). Overall, the net increase in carbon dioxide release following the application of biochar to soil appears to be a short – lived effect, while for incubations over a longer time period (>200 days), the average emission of carbon dioxide is usually not or even negatively affected for large application rates *(Sagrilo et al., 2014).* In a meta- analysis of forty-six studies, *Sagrilo et al. (2014)* showed that large additions of biochar relative to native soil organic carbon (SOC) content did not significantly affect for large application rates *(Sagrilo et al., 2014).Fbbri etal. (2012)* related the mineralization rates of twenty biochar to their chemical composition and found biochars with higher concentrations of proteins and sugars (from incomplete transformation by pyrolysis) to be associated with the largest mineralization rates. In contrast, biochar produced at a higher temperature resulted in lower carbon dioxide emissions *(Fabbri et al., 2012),* probably related to an increasing degree of aromatic condensation *(Keiluweit et al., 2010; Wiedemeier et al., 2015)* and the relative decrease of the labile fraction of biochar. To explain the result, *Sagrilo et al. (2014)* proposed that a major part of the labile fraction of biochar might have been consumed over two hundred days. Another possible explanation is that N deficiency eventually occurs after prolonged incubation of biochar amended soil *(Ameloot et al., 2015),* as most biochar have high C:N ratios. In their survey, *Sagrilo et al. (2014)* showed that soils with a C:N ratio < 10 were much more subject to an increase in carbon dioxide emissions after addition of biochar, which corroborates this assumption. Despite an already overwhelming number of studies on the effect of biochar on the soil biology and greenhouse gas emissions, most data originate from short – term experiments in the laboratory conditions *(Sagrilo et al., 2014),* although biochar persists in soil for centuries (Singh et al., 2012) and therein lies exactly its premise to abate net carbon dioxide emission. Since properties of biochar change over time *(Joseph etal., 2010),* long- term implications of biochar soil amendment are very likely to differ from short- term effects. For instance, positive priming has only been observed shortly after addition of fresh biochar to soil and does not seem to last over long periods of time *(Hamer et al., 2004; Wardle et al., 2008; Zimmerman et al., 2011).* More importantly, on long timescales after the addition of biochar to soil, a decrease of metabolic quotient defined as microbial activity reported to soil biomass or even a lower absolute amount of respired carbon was observed in biochar rich terra preta soils *(Jin, 2010; Liang et al., 2010).* Nevertheless, data from the Amazonia cannot be extrapolated to other soil and climate conditions with very different land – use histories. Additionally, several types of organic and inorganic household waste other than biochar were involved in the genesis of terra preta soils *(Glaser, 2007),* which makes it nearly impossible to isolate the effect of biochar from the effect of these other inputs. Very few studies have studied carbon turnover and soil biology at historic charcoal kiln sites in comparison with adjacent charcoal- free soils. *Kerre et al. (2017)* measured a smaller total of carbon dioxide emissions from soil than in reference soils and a smaller mineralization of fresh maize soil organic matter traced by ^{13}C isotope signature when added to a pre – industrial soil. As biochar application is mainly intended to cropland soils, these sites represent a critical source of information to unravel the long – term fate of biochar in soil and its effect on soil properties field experiment in agricultural soil *(Hardy et al., 2017; Kerre et al., 2017*). They related it to an increased sorption of dissolved organic carbon, with a preferential adsorption of the dissolved organic carbon rich in aromatics. Hence, proved by several scientists that biochar is produced by thermal decomposition of biomass under oxygen – limited conditions pyrolysis, and it has received attention in soil remediation and waste disposal in recent years. Biochar plays anvital role on growth and yield on agricultural crops.

How is biochar generated: Gasification is one of the dominant thermal decomposition processes producing gas along with biochar. Gasification is the process of converting solid fuels to gaseous fuel. The process involves drying, pyrolysis, combustion with air, reduction into combustible gases, (Carbon monoxide, hydrogen, methane, some higher hydrocarbons) and inert, (carbon dioxide and nitrogen). Biochar is produced from a range of organic materials under different conditions, showing variable properties *(Guerrero et al., 2005).* The currently used feedstock at a commercial scale and for different research facilities may include chips, pellets, bark of tree, and also the agricultural wastes including crop residues such as nutshells, straw, switch grass etc. The organic wastes including sugarcane bagasse, waste use of chicken litter proposed by *(Das et al; 2017)* and other biomassare dairy manure, as well as sewage and sludge. The agricultural waste biochar does not cause any notable greenhouse gas emissions. There are a considerably higher yield and porosity of biochar derived from the biomass having more lignin and lesser cellulose. *(Nartey and Zhao; 2014).* The biochar is produced by the thermal decomposition of waste biomass and the temperatures between 200-900° C in the presence of very little oxygen gas which is required for the biochar generation. The conversion of biomass into biochar takes place by the use of pyrolysis methods. The pyrolysis of waste biomass avoids the production of gasses like carbon dioxide and nitrogen oxide of greenhouse and also retains half of the carbon fixed by plants during photosynthesis. The biomass is helpful in the formation of biochar by slow or fast pyrolysis process and it also produces bioenergy as a byproduct. Bioenergy serves as an alternative form of fossil energy with low carbon dioxide emissions after combustion. The production of 35% biochar by pyrolysis, a maximum energy output of 8.7MJ kg^{-1} has been recorded in the form of bioenergy like liquid fuels *(Woolf; 2008), (Zhang et al; 2012).* Carbonized organic matter can essentially have different physical and chemical properties based on the technology eg. torrefaction, a pyrolytic process primarily at low temperature, slow pyrolysis, fast pyrolysis, gasification, hydrothermal carbonization, or flash carbonization used for its production. In contrast to considerable research, this has already been carried out to assess the value of biochar as soil amendment *(Luo et al;2013).*

Fast and slow pyrolysis

BIOMASS ---> BIOCHAR+ BIOENERGY

1.1 Characterization of Biochar

What good is biochar: For those who are interested in preparing bio-oil, the biochar often about 35% of the yield, it is a undesirable by- product. It is frequently burned to recover its energy content. We believe this is a waste of a valuable resource, having unique properties that are beneficial for agriculture. It makes more sense to obtain the energy otherwise. As well as documented in the order practices of natives in the Amazon and by modern studies in Asia, Europe, and the United States., there are great benefits arising from adding biochar to the soil. Some are enhancement of growth rates of plants and trees, greater quality and nutrient density of food crops. Decrease in needs for fertilizers, decrease in run-off of fertilizers to streams. The biochar in the soil remains as a stable solid for indefinite periods of time. The benefits greatly outweigh those derived from the energy that might be obtained by burning it. A good sustainable biochar is a powerfully simple tool that can fight global warming, produce a soil enhancer that holds carbon and makes soil more fertile, reduce agricultural waste, produce clean, renewable energy. In some biochar systems all four objectives can be met, while in others a combination of two or more objectives wills be obtained. The efficiency and effectiveness of the process of its creation and use can vary and the specific biomass sources used can affect the characterization and usability of the biochar *(McLaughlin et al., 2009).* It has been predicted that the stable portion of biochar has a mean residence time of greater than hundred years *(Spokas et al., 2013).* All biochar are not created equal they differ on their pH, surface are, Ash content, water holding capacity, cation exchange capacity (CEC), H/C ratio and C/N ratio. All a function of pyrolysis temperature highest treatment temperature (HTT), pyrolysis method, residence time and feedstock *(McLaughlin et al., 2009).* Following above characteristics are required for a good biochar.

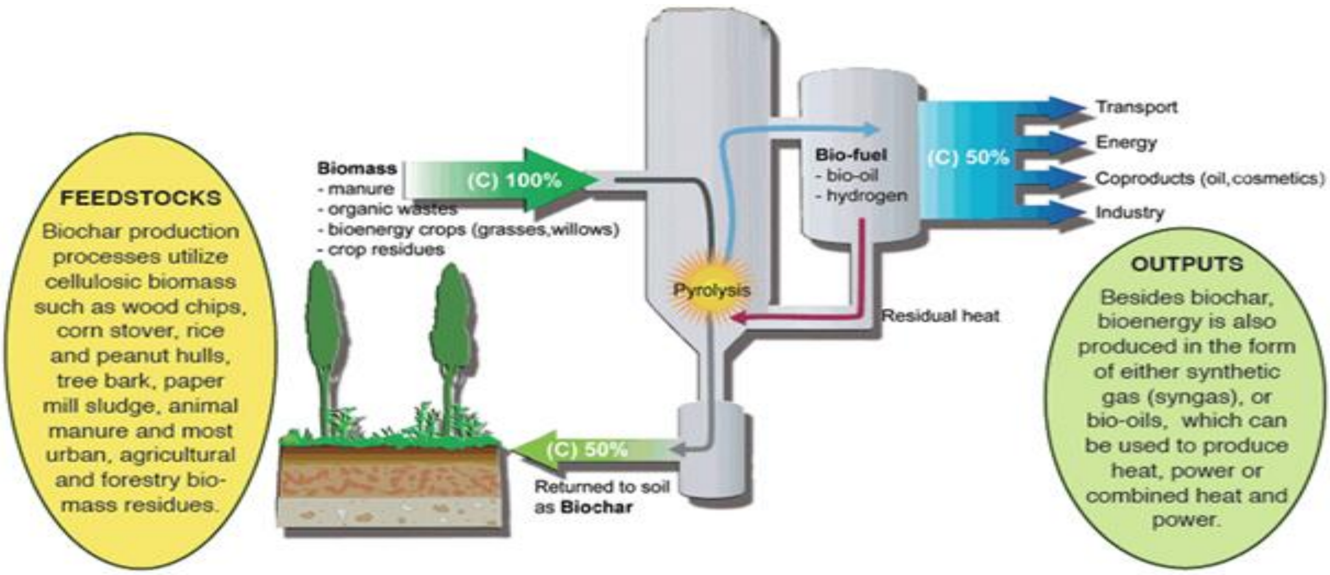

FIGURE 1: Manufacturing of Biochar.

Source: International Biochar initiative http://www.biochar-international.org/biochar/soils.

1.2 Quantification of biochar

Quantification major main is to distinguish biochar from soil organic matter and from other forms of black carbons produced from varieties of biomasses. Many of the potential techniques depend on spectroscopic from soil organic matter and from varieties of biomasses. Many of the potential techniques depend on spectroscopic characteristics rather than physical separation or isolation. Some of the techniques that most effectively distinguish types of biochar can also be used to characterize individual biochar wastes or collection of fragments recovered from both soil and solution systems. An assessment of pure samples removes the matrix effects, but where function of a recalcitrant component depends on its surface characteristics or those of accessible pores, separation of active and inactive components presents a significant challenge *(Lou and Yang et al., 2012).* Classifying biochar is principally problematic on the basis of its chemical complexity and diversity, yet characteristically uncreative nature. Due to its recalcitrance nature, biochar cannot eloquently be extracted from soil using chemical methods, though potential biomarkers may be. The result from studies using the physical location of biochar within a soil matrix *(Smernik et al., 2002, Kroger et al., 2013)* suggest that usefulness of physical separations using density or means other than hand sampling approach which is restricted to very small samples is susceptible to site factors. There is no difference of biochar age on soil physical and chemical properties. Biochar able to maintain structure as a stable lattice network. Strong ability to retain hydrocarbons and other organic compounds. High physical adsorption capacity within the macro pores to micro pores.

TABLE 1
ORGANIC CONTAMINATES ADSORBED BY BIOCHAR PRODUCED FROM DIFFERENT BIOMASS.

Source of Bio-char	Organic pollutant sorbed	References
Pine needle	Naphthalene, nitrobenzene, and m-dinitrobenzene from waste water.	B.L. Chen et al., (2008)
Bamboo	Pentachlorophenol	Lou and Yang et al., (2012)
Bamboo, Brazilian pepper wood and sugarcane bagasse.	Sulfamethoxazole from waste water.	Yao et al., (2012)
Wheat straw	Hexachlorobenzene	Wild et al., (2012)
Hardwood, Softwood and grass	Ctechol and humic acid	Zimmerman et al., (2010)

1.3 Properties of Biochar

Biochar is commonly alkaline. The pH values of biochar at different pyrolysis temperature ranged from slightly alkaline (=8.2) to highly alkaline (=11.5) across a wide variety of feedstocks *(Yaun et al. 2011).* Biochar shows positive effect in the case of acidic soils compared to alkaline soils *(Biederman and Harpole 2013).* Biochar addition can reduce the bioavailability of toxic forms of Al, Cu, and Mn and increase the availability of essential nutrients such as Na, K, Ca, Mg, and Mo, thereby rendering a favorable environment for plant growth *(Altkinson et al.2010).* The physical structure of biochar can be described by scanning electron microscopy (SEM). The physiochemical properties of biochar vary with the temperature at which it forms and the type of feedstock involve in its production. Most of the biochar is produced at the temperature between 300°C to 500°C possess alkaline pH *(Brown et al., 20211)*and also depending on the type of feedstocks, the biochar prevails PH range of 6.1 to 11.6 which is considered to be alkaline. This alkaline character of biochar is due to the presence of carbonates and alkaline elements such sodium, potash, calcium and magnesium present, which forms during thermo-chemical conversion of the biomass. The other properties of biochar due to its alkaline nature are the high total carbon content which is reflected in C:N ratio of 200:1 and lower total nitrogen 1.3 g kg^{-1}*(Chen et al., 2008).* The type of feedstock used for the biochar also affects the energy content of biochar which may range from 30 to 35 $MJkg^{-1}$*(Ryu et al., 2015). (Sohi et al., 2010)* observed that the ash content of this black material also increases with increasing temperature.

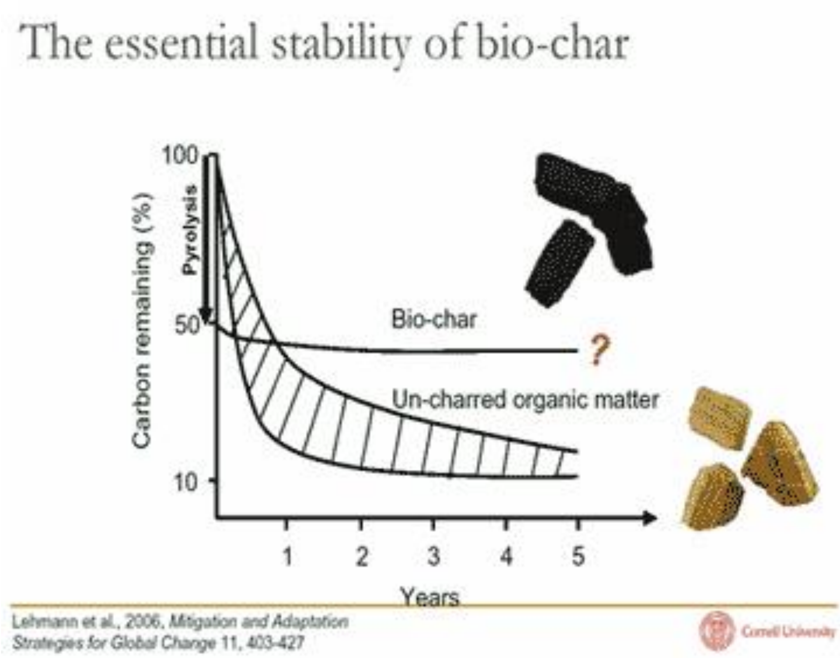

FIGURE 2: The essential stability of Bio-char.

Source: international Biochar initiative http://www.biochar-international.org/biochar/soils

II. BIOCHAR AND THE ENVIRONMENT

Stability of biochar relates to carbon structure, as it constitutes the carbon structure. It is the main factor that must be focused on prior application is stability. Biochar is utilized for many purposes, its influence on the environment must be analysed properly to avoid its negative impacts *(Cross and Sohi., 2013).* The dissolved organic matter released from biochar maintains a high degree of aromaticity, resistance and stability. When biochar is utilized for treating wastewater, the carbon content of water increases due to the release of carbon by biochar. The biochar produced from sludge containing heavy metals may percolate during the treatment process thus causing heavy metal contamination. Aromaticity and aromatic condensation are the main measures of biochar carbon structures *(Vikrant et al., 2018).* When the biochar acts as a catalyst, the stability gradually decreases on reusing biochar several times. The instability of biochar may be due to structural damage also. Hence, stability of biochar plays an important role in the environmental concern. In addition, the toxicity of biochar to soil microbes must be investigated before application *(Premarathna et al., 2019). (Gong etal., 2019)* observed that the physicochemical properties of biochar vary with different biomass, it is important to study in detail the toxic effects of biochar on environment. A different toxicity test can be performed using fungi, algae, bacteria, fish etc. *(Venegars etal., 2016)* suggested that supporting carbon sequestration and reducing the effect of green house gases. Biochar is a powerful simple tool to fight global warming. Transfers agricultural waste into a soil enhancer that can hold carbon, boost food security, and discourage deforestation *(Biochar International 2012).*Biochar have potentially to enhance seed germination and plants growth which very benefical and significant for making our environment green and clean, while some biochar could have negative influence too.

III. EFFECT OF BIOCHAR ON AGRICULTURE FIELD

Biochar enhances the heath of soil and agricultural crops as well. Increases the pH of acidic soil since, biochar is typically alkaline. It also increases the water and nutrient retention of soil. Biochar carbon is chemically altered during gasification and thus are resistant to attack by micro-organisms. Biochar carbon can remain stabilized for long years of time hundred to thousand years. Is therefore an important way of storing carbon that has been scavenged from the atmosphere during photosynthesis. Biochar may have the potential to reduce leaching of nutrients from agricultural soils(Lehmann et al., 2007). This possibility is suggested by the strong adsorption affinity of biochar for soluble nutrients such as ammonium, nitrate, phosphate and other ionic solutes *(Radovic et al., 2001).Lehman et al (2003*) found that “cumulative leaching of mineral N, K and Mg in the Amazonian Dark Earth was only 24, 45 and 7%, respectively, of that found in a Ferralsol.All biochar showed significant increase in soil organic matter rather than control. Biochar did not show any significant effect on moisture content of soil. Kadam biochar showed relatively less changes in soil nitrogen and phosphorus compared to other. Activated biochar is added into soils of agricultural field to improve soil structure. Biochar itself is a porous material, it can adsorbed and retain huge amount of water. Research suggests that even low rates of biochar application can significantly increase crop productivity *(Winsley., 2007).* The biochar application in soil not only helped in isolating carbon in soil, it also enhanced the quality of soil by neutralizing the pH, increasing soil cation exchange capacity and strengthening the microbial growth in soil. The functional groups such as carboxylic, hydroxyl and phenolic groups present in biochar interacts with hydrogen ions in soil and reduces concentration of hydrogen ions in soil and reduces concentration of hydrogen ion thus increasing the pH. Carbonates, bio-carbonates and silicates in biochar react with hydrogen ions and neutralizes soil pH *(Ahmad et al., 2012).* Hence, biochar application in remediating soil in agricultural fields has increased interest owing to its surface properties, elemental composition, enhancing the soil fertility and improving crop productivity.

IV. USE OF BIOCHAR TO MANAGE WATER QUALITY

Biochar may be beneficially take the edge off spread contamination arising from farming all the time distribution in solumn from which adulterating essential come to light. It could possibly to make use of its natural action magnitude to flash out the pollutants in the water reception procedure. Disquisition a particular illustrate the volume for bio-char to separate the nitrates ***(Mizuta, 2004***) and phosphate ***(Beaton, 1960)*** in this circumstances has been adverted, and in over-passing the convolution of the soil system, squeeze ability is registered.

V. BIOCHAR IN THE TIME OF CORONAVIRUS

Density of people have lost asked that if how can biochar will be helpful during this pandemic. Accommodating a contagion that has departed intercontinental is an entirely dissimilar calamity. Nonetheless, there are other ways that biochar can be beneficial to help. Masks made with biochar activated carbon have long been used in personal protective gear (PPE) and there is some indication that certain types of carbon may be effective in activated viruses ***(Matsushita et al 2013).*** A truly innovative, reusable mask that contains biochar which could be made in mobile manufacturing faculties was pioneered. Carbonizing contaminated medical waste, the high heat temperatures should eliminate the virus and the resulting biochar could be used for a variety purposes including potentially masks. Carbonizing human feces, there is some indication that human feces may contain traces of virus through more needed. To be on the safe side, putting sludge through a thermo-chemical conversion system would eliminate the risk and also provide substantial other benefits as well.

VI. CARBONIZATION VERSUS CREMATION

Funeral homes are overloaded in hot spot zones for the pandemic. Through the concept of carbonizing human remains is still largely theoretical, it is feasible. Keeping part of a loved-one's carbon from returning to the atmosphere might seem like purgatory to some, but it might be one small way to help rebalance carbon levels. Farmers in the Northern Hemisphere are just about ready to start planting and going without fertilizer is causing many to panic. However, those that know how to convert biomass to biochar and blend it with locally available nutrients such as manure, compost, urine, compost, etc. can wean themselves off their dependency on imported fertilizer. This not only increases their resiliency but also reduces costs and emissions related to fertilizer use. It can also alleviate leaching of excess nutrients into local water bodies.

VII. CONCLUSION

This concluded that the efficient use of biochar by converting it as a useful source of soil amendment is one way to manage the soil health, fertility and crop productivity. One of the approaches for efficient utilization of biochar involves carbonization of biomass to highly stable carbon compound biochar. Use of biochar in the agricultural systems is one viable option that enhances the nutrient availability, increases soil carbon levels, moisture retention, cation exchange capacity, improve soil quality and natural rate of carbon sequestration in the soil. Biochar reduces the emission gasses, decreases toxicity of aluminium and other metals, decrease tensile strength and bulk density of soil and provides numerous benefits to the soil. Measurable and verifiable improves agricultural productivity. Research gaps are still an evident and hold strong ethics to the people. Further, inter -disciplinary research has to be taken up for studying the long term impact of biochar application on soil physical properties, nutrient availability, soil microbial activities, carbon sequestration potential, crop productivity and green house mitigation.

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