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Review of Biochar Applications in the Soil

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ABSTRACT
Biochar is a stable solid, rich in carbon, and can endure in soil for thousands of years. Like most charcoal, biochar is made from biomass by pyrolysis method.Biochar has the potential to mitigate the climate change by Carbon sequestration. Biochar can increase soil fertility. It also helps to improve the acidic soil by minimising the pH, increase agricultural productivity, and provide protection against some foliar and soil-borne diseases.Biochar is produced in an environmentally friendly manner by recycling plant waste into fertilizer. Nitrogen is a significant factor in crop growth, and the use of biochar as a source of soil nitrogen has been a subject of much study. The direct application of biochar as nitrogenous fertilizer is inefficacious because biochar contains more carbon than nitrogen. Instead, the porosity and large surface area of biochar is effective at retaining nitrogen compounds and inhibiting its leaching by runoff. Biochar can improve almost any soil. Areas with low rainfall or nutrient-poor soils will most likely see the largest impact from addition of biochar.
Keywords:- *Pyrolysis, Carbon sequestration, crop growth, climate change, leaching, recycling*

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INTRODUCTION

The carbon in biochar resists degradation and can hold carbon in soils for hundreds to thousands of years. Biochar is produced through pyrolysis or gasification processes that heat biomass in the absence (or under reduction) of oxygen. It is used as a soil enhancer;sustainable biochar practices can produce oil and gas by-products that can be used as fuel, providing clean, renewable energy. When the biochar is buried in the ground as a soil enhancer, the system can become "carbon negative." Biochar and bio-energy co-production can help combat global climate change by displacing fossil fuel use and by sequestering carbon instable soil carbon pools. It may also reduce emissions of nitrous oxide. Biochar can be an important tool to increase food security and cropland diversity in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertilizer supplies. Biochar also improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop utilization. biochar is an effective sequestration and bioremediation tool in reducing the emission of pollutants while improving soil quality [1-6].

Nitrogen is one of the most important nutrients. In soil, the majority of nitrogen exists in complex organic forms; before it can be incorporated by the plant, it must be ammonified to $NH4^{+}$ and then nitrified to $NO3^{-2}$. Thus, it is inevitable that the nitrogen cycle will remove much of the soil's nitrogen before the plant can even use it through either the discharge of gaseous nitrogen dioxide or the leaching of nitrates by water runoff [7, 8].

According to the research to date, biochar has the potential to control the rates of nitrogen cycling is carried in three ways i.e. enhancing the soil content of $NH4^{+}$ and $NO3^{-}$ through direct adsorption by the biochar, reducing the emission of N2O and losses of nitrogen

leaching and increasing the population of nitrifying soil bacteria for biological N retention. When the biochar has a smaller particle size and a larger surface area that condition enhances the soil content of $NH4^+$ and $NO3^-$ through direct adsorption by the biochar and reduces the emission of N2O and losses of nitrogen leaching are improved. The population of nitrifying soil bacteria is increases by both surface area and high pH [9-12].

MODIFICATION OF THE SOIL HABITAT BY BIOCHAR

The material properties of biochar are very different from those of uncharred organic matter in soil, and are known to change over time due to weathering processes, interactions with soil mineral and organic matter and oxidation by microorganisms in soil. However, the relationships between biochar chemical and physical properties and their effects on soil biota and potential concomitant effects on soil processes are poorly understood. This section gives a brief overview of the unique properties of biochars compared to other compounds in soil as a background to the following sections that discuss the effects of biochar on soil biota [13, 14].

BIOCHAR PHYSICAL PROPERTIES

Biochar application can also change soil bulk density with possible effects on soil water relations, rooting patterns and soil fauna. This occurs both because the density of biochar is lower than that of some minerals, and because biochar contains macro- and micropores**,** which can hold air or water, greatly reducing the bulk density of the entire biochar particle. Surprisingly little bulk density data have been published for biochar or natural char samples. Density measurements for biochar should distinguish between the true, solid particle density and the bulk density of the biochar particles increase their pore space[2, 15, 17].

CHEMICAL PROPERTIES

Organic Carbon: The increase in soil organic carbon with application of biochar might have resulted from recalcitrant nature of carbon found in biochar which is largely resistant to decomposition. The soil carbon increased significantly over control. Also Biochar application increased soil organic carbon content. Available N, P and K: Applying biochar to forest soils along with natural or synthetic fertilizers has been found to increase the bioavailability and plant uptake of phosphorus (P), alkaline metals and some trace metals, but the mechanisms for these increases are still a matter of speculation.In the manufacture of the Nitrogen enriched biochar, biocharproduced at a lower temperature of 400 °C to 500 °C is more effective in adsorbing ammonia than that produced at higher temperatures (700 °C to 1000°) [16].

Biological activity

Biocharalone has a significant effect on soil enzymatic activity. The quoted authors proved that poultry litter biochar produced at 400 Cand amended to soil @ 20 t/ha caused a significant increase in the activity of dehydrogenases. Biochar has positive effect onmycorrhizal association when applied to soil [17].

Interaction between roots and biochar

When biochar was a direct source of nutrients, biochar increased nitrogen retention in the rhizosphere and bulk soils through indirectinteractions. The roots grew towards the biochar, while the biochar altered the nutrient content ofthe soil closest to itself. In addition, by reducing the nitrogen content of the biochar, weatheringalso reduced the nitrogen retained in the soil, indicating that the nutrient content of biochar is animportant factor in root-biochar interaction [18].

Plant Growth as affected by Application of Biochar and FYM

The application of biochar along with FYM to the soil, plant growth was significantly higher .This was attributed to the effect of biochar on soil, which largely influence the accumulation of Soil Organic Matter and improves other soil chemical properties, such as pH, which ultimately enhanced the quality and productivity of degraded and low quality soils.The application of biochar to the soils had positive effects on plant growth by improving soil nutrient availability, water holding capacity, carbon sequestration, CEC and soils pH level [19].

Biochar use in soil

Biochar enhances soils. By converting agricultural waste into a powerful soil enhancer that holds carbon and makes soils more fertile, we can boost food security, discourage deforestation and preserve cropland diversity. Research is now confirming benefits that include:

- Reduced leaching of nitrogen into ground water
- Possible reduced emissions of nitrous oxide
- Increased cation-exchange capacity resulting in improved soil fertility
- Moderating of soil acidity Increased water retention
- Increased number of beneficial soil microbes

CONCLUSIONS

The results of this study indicated that a significant improvement in soil properties (Soil Organic Matter and pH), crop growth rate and productivity could be attributed to the effect of biochar and FYM application on a degraded soil in a coffee agroforestry system. While it was noted that biochar applied at low rates along with FYM generally has immediate positive effects on the vegetative growth of plants, soil properties and overall crop yields may, however, take a longer time to show improvement. Future long-term research is needed to confirm the benefits of biochar amendment on soil quality and crop yields and productivity.

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