Biochar: Improving Soil Fertility and Crop Productivity

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ABSTRACT

Although more people are fed by intensive farming the soil eventually deteriorates as a result of erosion nutrient loss and decreased yield. Using biochar a substance that resembles charcoal and is produced by heating agricultural leftovers or other organic wastes without oxygen is one of the eco-friendly methods for restoring soil health. By improving soil structure increasing water-holding capacity and providing locations where nutrients can be retained rather than percolating away biochar helps mitigate climate change in a number of ways. It also keeps carbon in the earth for a very long time. It has been demonstrated to immobilize heavy metals by decreasing their bioavailability for plants in addition to improving the physical chemical and biological characteristics of the soil. Higher crop yields and better root growth are usually the results.

INTRODUCTION

Biochar is used as a long-lasting soil amendment that enhances crop performance and soil health. Biochar improves soil aggregation water-holding capacity and nutrient retention due to its large surface area and stable carbon structure which promotes improved root development and plant productivity. Biochar increases soil organic carbon in many degraded or nutrient-poor soils reduces acidity and produces ideal microhabitat for beneficial microorganisms. It has been shown to improve the physical, chemical and biological properties of the soil and immobilize heavy metals by reducing their bioavailability for plants. Biochar is a useful tool for long-term carbon sequestration and

climate-smart agriculture because of its recalcitrant nature which permits it to remain in soils for decades to centuries in addition to increasing soil fertility and yields. Nowadays farmers all over the world are turning to biochar as an inexpensive environmentally friendly way to increase their harvests.

What is Biochar?

Pyrolysis is the process of heating biomass such as wood manure or crop residues under low oxygen levels to create biochar, a porous carbon-rich substance. Biochar is the unique product that improves the nutrients available to plants which increases the crop yield considerably. Biochar is a residue with fine particles having high carbon content which functions as a carbon sequestrator and soil conditioner (Lehmann, 2007). Additionally, biochar increases the methanotrophic network and decreases the methanogens that produce methane in soil (Singh *et al*., 2017) thus reduces GHG emission.

How Biochar Enriches Soil Fertility:

The application of biochar increased the soils organic carbon and water-holding capacity which improved the availability of nutrients. It enhances the exchange of nutrients between the soil and plant roots allowing crops to more efficiently absorb potassium phosphorus and nitrogen (Premalatha *et al*., 2023). Micronutrients like boron, molybdenum, K, P, calcium and others can be found in biochar (Rondon *et al*., 2007). These elements are necessary for rhizobia nodulation (Gabhane *et al*., 2020).

Biochar's Role in Improving Soli Structure:

The application of biochar transforms platy soil into granular or crumb structures that are ideal for farming (Premalatha *et al*., 2023). Hard soils become looser and sandy soils become more stable with the addition of biochar. Biochar when mixed with soil creates small pores and channels through which moisture flow, soil aeration and root movement take place.

Water Retention - A Key Benefit of Biochar:

Water quality soil moisture retention and plant water availability were all improved by adding biochar as a soil amendment. In contrast to clayey soils the application of biochar increased the amount of water available to plants in sandy soils (Glaser *et al*., 2002). According to Herath *et al*., 2013, Applying biochar lowers the bulk density of the soil and increases the rate of infiltration by increasing the soils overall porosity.

Boosting Plant Growth and Productivity:

The application of biochar increased crop yield, root density and seed germination. Crop yield was increased by applying biochar at higher doses in conjunction with chemical fertilizers (NPK) (Premalatha *et al*., 2023). Applying biochar greatly increased crop yields with and without nitrogen fertilizer demonstrating its capacity to enhance soil quality and nutrient availability. Biochar demonstrated strong synergistic effects when mixed with nitrogen fertilizer leading to even higher yield increases (Yamato *et al*., 2006).

Biochar and Soil Microbial Activity:

Soil microbial biomass serves as the main indicator of microbial diversity and soil productivity. Microbial biomass provides plants with access to a labile nutrient pool and is crucial for soil nutrient transformations in addition to carrying nutrient cycles (Liu *et al*. 2010). When biochar is added to agricultural fields soil microbial biomass responds. Since the stability period of biochar in soil is believed to be many years, the size and properties of microbial biomass may change over a long period of time (Singh *et al*., 2017).

Reducing Fertilizer Requirement:

Biochar naturally reduces the need for fertilizer by boosting the soils overall fertility and nutrient efficiency. Essential nutrients are retained and cannot be lost through volatilization or leaching due to its porous structure which acts like a sponge. Crops have longer access to nutrients as a result. Additionally, biochar improves the soils cation exchange capacity (CEC) which facilitates the more efficient storage and release of nutrients (Premalatha *et al*. in 2023). It encourages the growth of helpful microbes that improve nutrient cycling and release nutrients that plants havent been able to obtain (Gabhane *et al*. (2020). Furthermore, biochar enhances soil aeration moisture retention and structure—all of which promote root development and nutrient uptake. In order to produce healthy yields plants, grow more efficiently and require less chemical fertilizer.

Farmer-Friendly Ways to Apply Biochar:

Biochar can be applied by farmers in a number of easy and efficient ways to enhance soil health. It is common practice to mix biochar with compost or manure before applying the material to make it more active in the soil and help it absorb nutrients. Farmers apply biochar to the field and plow or till it into the topsoil as part of the land preparation process. Small amounts of biochar are applied directly in planting pits or along seed rows for crops like vegetables and fruit trees. In order to improve fertilizer efficiency and minimize nutrient loss farmers also mix chemical fertilizers with biochar. In nurseries adding a small amount of biochar to the soil mixture improves aeration and seedling growth. Applying small doses each season yields long-term benefits.

Biochar-A Longterm Solution for Soil Health:

Biochar is a key component in lowering pollution and raising soil carbon levels. Because of its porous structure biochar functions as a sponge trapping heavy metals pesticides and hazardous chemicals to keep them out of groundwater (Premalatha *et al*., 2023). Additionally, it improves soil aeration and microbial balance which lowers greenhouse gas emissions like methane (Singh *et al*., 2017) and nitrous oxide. Because biochar prevents nutrient leaching nitrogen and phosphorus stay in the soil rather than contaminating rivers and lakes. By trapping carbon in a stable form that remains in the soil for hundreds of years biochar also increases carbon storage. It stops crop residues from breaking down quickly turning them into carbon that lasts a long time. This promotes sustainable agriculture increases fertility and increases soil organic carbon.

CONCLUSION:

The use of biochar to increase soil fertility and productivity has proven to be very successful and sustainable. Its porous structure improves soil aeration water-holding ability and nutrient retention fostering a more favorable environment for root development and beneficial microbes. Biochar guarantees that plants receive a consistent supply of vital nutrients by lowering nutrient losses and maintaining soil pH which improves crop performance. Its long-term carbon stability encourages climate-friendly farming and aids in the restoration of damaged soils. All things considered biochar is a valuable solution for productive and sustainable agriculture since it not only improves soil health but also supports higher and more consistent yields.

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