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Biochar in agriculture: Harnessing the power of charcoal for sustainable farming

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Abstract

Biochar is a type of charcoal produced from organic waste materials, such as wood chips or agricultural residues. In agriculture, biochar is used as a soil amendment to improve soil health and fertility. It has several benefits, including enhancing soil structure, reducing nutrient leaching, and increasing water retention capacity. Additionally, biochar can sequester carbon in the soil, potentially contributing to mitigating climate change. The use of biochar in agriculture is an environmentally friendly practice that promotes sustainable farming methods.

Keywords: Biochar, charcoal, soil amendment, environment friendly

Introduction

With the global population on the rise and soil degradation becoming a significant concern, finding sustainable solutions for agriculture is more critical than ever. One such solution gaining recognition is biochar. Derived from the age-old practice of charring organic matter, biochar offers immense potential for improving soil health, enhancing crop productivity, and mitigating climate change. Biochar is a fascinating substance that has gained significant attention in recent years due to its potential benefits for the environment and agriculture. Derived from the process called pyrolysis, biochar is a type of charcoal produced by heating organic materials, such as wood, crop residues, or animal manure, in a low-oxygen environment. This thermal conversion process transforms the organic matter into a stable carbon-rich material known as biochar (Lehmann and Joseph, 2009)^[6].

Biochar has been used for centuries in traditional agricultural practices in regions like the Amazon basin, where ancient civilizations created vast areas of nutrient-rich soil called "terra preta" by incorporating biochar into the soil. Today, the potential of biochar is being explored for addressing modern environmental challenges and promoting sustainable farming practices (Lehmann and Joseph, 2009)^[6].

One of the key benefits of biochar is its ability to sequester carbon dioxide (CO₂) from the atmosphere. When organic material is transformed into biochar through pyrolysis, a significant amount of the carbon that was once stored in the plants is retained in the biochar, preventing it from being released into the atmosphere as CO₂. This makes biochar a promising tool in the efforts to combat climate change by reducing greenhouse gas emissions (Pak *et al.*, 2016)^[7].

In addition to its carbon sequestration potential, biochar can significantly improve soil health and productivity. When biochar is incorporated into the soil, it enhances its ability to retain water, nutrients, and beneficial microorganisms. This increased water and nutrient retention capacity can lead to improved crop growth, reduced irrigation needs, and decreased nutrient leaching, thus promoting sustainable agriculture (Jha *et al.*, 2010)^[5].

Furthermore, biochar can enhance soil fertility by increasing the availability of essential plant nutrients, such as nitrogen, phosphorus, and potassium. It acts as a porous structure, providing a habitat for beneficial microorganisms that support plant growth. By improving soil fertility and structure, biochar can contribute to increased crop yields and overall food production (Atkinson *et al.*, 2010)^[1].

Biochar also has the potential to remediate contaminated soils and water. Its porous structure and high surface area enable it to adsorb and retain various pollutants, including heavy metals and organic compounds. By introducing biochar into contaminated areas, it can help reduce the concentration of these harmful substances, mitigating their impact on the environment and human health (Chan *et al.*, 2008)^[3].

Furthermore, biochar can be utilized as a renewable energy source. During the pyrolysis process, heat and gases are released, which can be harnessed for various energy applications, including heat and electricity production. This makes biochar a valuable by product of bioenergy production systems, contributing to the development of sustainable energy solutions (Spokas *et al.*, 2010)^[8].

Despite the numerous potential benefits of biochar, there are still areas that require further research and exploration. Factors such as biochar production methods, feedstock selection, and application rates need to be studied to maximize its effectiveness and minimize any potential negative impacts. Additionally, the long-term stability of biochar in different soil types and climates requires investigation to ensure its sustainability and durability (Van Zwieten *et al.*, 2010)^[9].



Understanding Biochar

Biochar is a form of charcoal produced through a process called pyrolysis. Biomass, such as agricultural waste, wood chips, or manure, is heated in a low-oxygen environment to create biochar. It differs from traditional charcoal in that it is specifically designed for soil enhancement rather than fuel. When implemented correctly, biochar can remain in the soil for hundreds or even thousands of years.

1. Enhancing Soil Fertility

One of the primary benefits of biochar lies in its ability to enhance soil fertility. When incorporated into the soil, biochar acts as a sponge, retaining moisture and essential nutrients. Its porous structure provides a habitat for beneficial microorganisms, promoting a healthy soil ecosystem. Additionally, biochar reduces nutrient leaching, ensuring that fertilizers stay available to plants for longer periods, which subsequently improves crop productivity. (Lehmann and Joseph, 2009)^[6].

2. Carbon Sequestration

Biochar also plays a significant role in mitigating climate change. By sequestering carbon in the soil, it helps reduce greenhouse gas emissions. When organic matter decomposes naturally, it releases carbon dioxide (CO₂) into the atmosphere. However, when that same biomass is converted into biochar, it locks in the carbon, preventing its release into the atmosphere. This carbon-negative process has the potential to offset emissions while contributing to long-term carbon storage. (Cayuela *et al.*, 2008)^[3].

3. Improving Soil Health

The introduction of biochar into agricultural soils has shown promising results in improving overall soil health. It helps increase soil pH, especially in acidic soils, making them more favorable for plant growth. Biochar also improves soil

structure by creating pore spaces, enhancing water infiltration, reducing erosion, and preventing soil compaction. All these factors contribute to healthier root systems and more resilient plants. (Van Zwieten *et al.*, 2010)^[9].

4. Water Management

In regions prone to drought or excessive rainfall, biochar can significantly improve water management. The high porosity of biochar allows it to absorb and retain excess water during wet periods, reducing the risk of waterlogging and nutrient runoff. During dry spells, it gradually releases stored moisture, providing a steady water supply to plants. This water buffering capacity enhances crop resilience in the face of unpredictable weather patterns, making biochar a valuable asset in combating climate change. (Jeffery *et al.*, 2016).

Application Methods

Biochar can be applied to soil through various methods, with each approach having its own benefits and considerations. Here are some common application methods of biochar:

- 1. Broadcast Application:** This method involves spreading biochar evenly over the soil surface, followed by incorporation through tillage or natural processes like rainfall and soil organisms. Broadcast application is suitable for large-scale operations and can be used for both bare soil and established crops. However, it may require more biochar to achieve desired effects compared to other methods.
- 2. Incorporation:** Biochar can be mechanically incorporated into the soil using tillage equipment, such as plows or rotary cultivators. This ensures a more thorough distribution of biochar throughout the root zone. Incorporation can be done prior to planting or during the growing season, allowing direct contact between biochar and plant roots. It is important to consider the appropriate depth and timing to minimize disruption to soil structure and existing crop roots.
- 3. Furrow Application:** In this method, biochar is applied directly into furrows or rows where seeds or transplants are placed. This allows biochar to be in close proximity to the roots, enhancing nutrient and water uptake. Furrow application is common in row-crop systems, where biochar can be placed below the seed or transplant during planting. It is essential to ensure good seed-to-soil contact and prevent concentrated biochar application that may cause seedling damage.
- 4. Pot or Container Application:** Biochar can also be incorporated into potting mixes or container media for horticultural crops. It helps improve drainage, nutrient retention, and root development in confined growing environments. Typically, biochar is blended with other organic materials and added to the potting mix during production or planting.
- 5. Composting:** Another method involves incorporating biochar into the composting process. Mix biochar with organic waste, such as crop residues or animal manure, during composting. The high temperatures and microbial activity during the composting process help charge the biochar with nutrients and beneficial microorganisms, enriching the final compost product.

Method and preparation of biochar

Here are the steps involved in preparing biochar using the traditional method.

1. Gather the necessary materials and equipment:

- Biomass: Choose carbon-rich organic waste materials like wood chips, crop residues, sawdust, grass clippings, or agricultural waste.
- Container: Select a sturdy and heat-resistant container like a metal drum or insulated kiln.
- Air-tight seals: Use materials like clay, sand, or oven gasket seals to close any gaps or openings.
- Heating source: A heat source such as an open fire, gas burner, or electric heating elements.

**2. Prepare the container:**

- Clean the container and ensure it is free from contaminants.
- Close any gaps or openings in the container using air-tight seals to restrict oxygen flow.

**3. Load the biomass:**

- Fill the container with the selected biomass, avoiding overcrowding for better heat distribution.

**4. Ignite and heat:**

- Light the fire under the container to initiate the heating process.
- Gradually increase the temperature, closely monitoring the process.
- Maintain a low-oxygen environment within the container by adjusting airflow and sealing any leaks.

**5. Pyrolysis process:**

- As the temperature rises, the biomass will decompose.
- Volatile components vaporize and escape, leaving behind carbon-rich biochar.
- This process typically takes several hours and varies based on factors like biomass type, container size, and heat source.

**6. Cool and store:**

- Extinguish the fire and allow the container to cool down.
- Avoid exposing the biochar to excessive moisture.
- Once cooled, store the biochar in a dry and covered area until ready for use.

Conclusion

Biochar offers an eco-friendly and sustainable solution for the challenges facing modern agriculture. Its ability to improve soil fertility, enhance water retention, sequester carbon, and promote a healthy soil ecosystem has garnered significant attention within the farming community. As the world seeks innovative ways to feed a growing population while minimizing environmental impact, biochar presents a valuable tool in the path towards sustainable agriculture. By adopting biochar practices, farmers can not only cultivate healthier crops but also contribute to mitigating climate change and preserving our precious planet for future generations.

By harnessing the power of charcoal through biochar, we can ensure the long-term sustainability and resilience of our agricultural systems. Embracing this ancient practice in a modern context signifies our commitment to creating a greener, more sustainable future for generations to come.

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