An Introduction to Biochar and its Potential Use

What is biochar?

Biochar is a black charcoal material produced from biomass (wood, corn husks, poultry manure, etc.) heated at elevated temperatures and limited oxygen supply, a process called pyrolysis. Biochar is different from traditional charcoal, as it is manufactured for use as a soil amendment instead of a fuel for cooking. Biochar also can be derived as a byproduct of biofuel production. Biochar can be made from varied materials, with switchgrass, mixed woods, rice hulls, and oakwood being the most common. Plant waste is a common source for biochar, but animal and municipal wastes also can be used.

Though study of biochar is a newer field of research, its history dates back centuries. Terra preta soils were discovered in the Amazon Basin, which consist of charred organic matter. Nutrient retention is high in these soils, which tend to have a neutral pH in areas that are surrounded by acidic soils. These soils tend to exist in inhabited locations, giving way to the idea that their creation was a result of human intervention, though this is not confirmed. These soils are likened to those amended with biochar, though the soils of the Amazonian Basin have had more time to develop and interact with the charred organic matter that exists in that area.

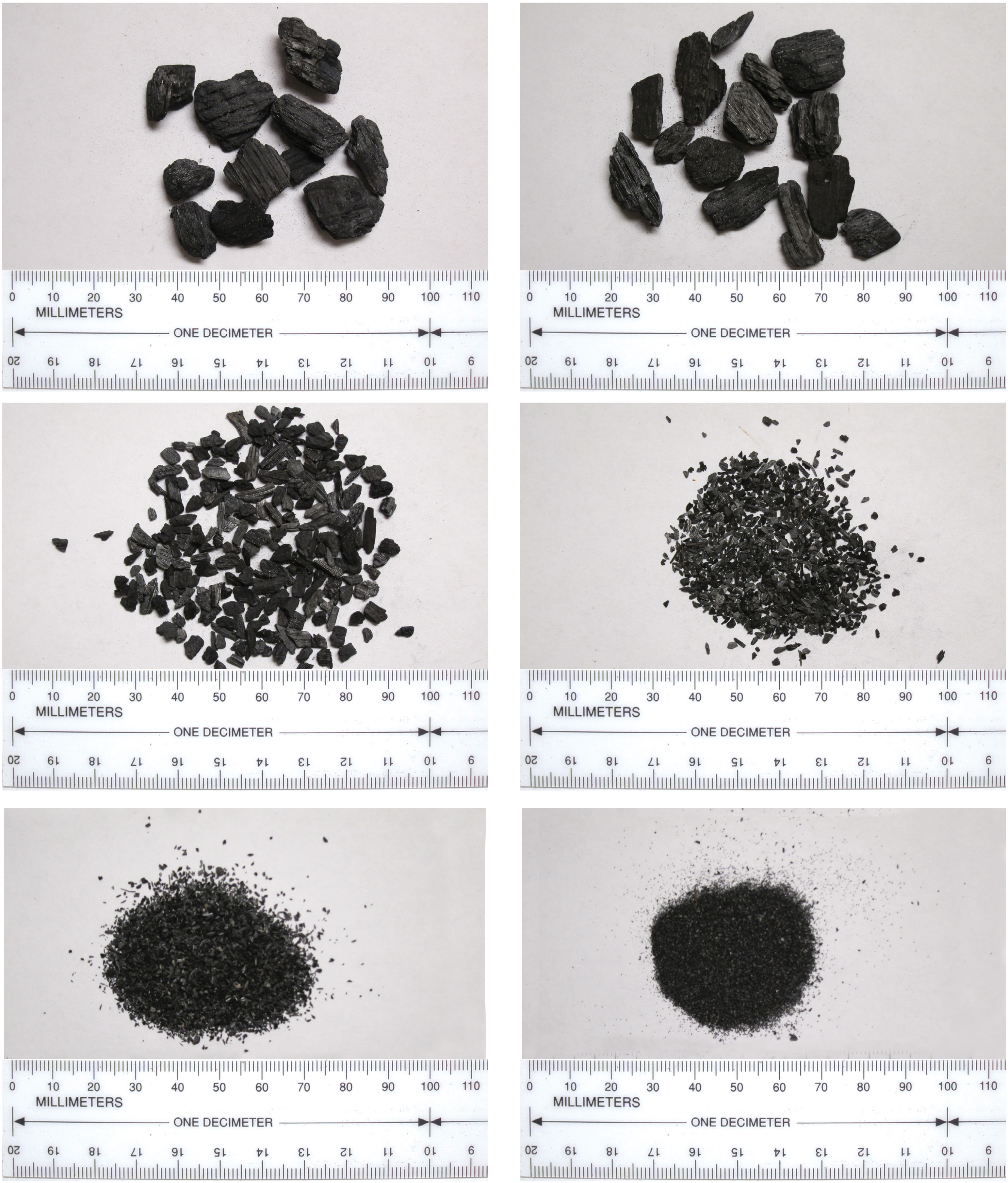
How is biochar made?

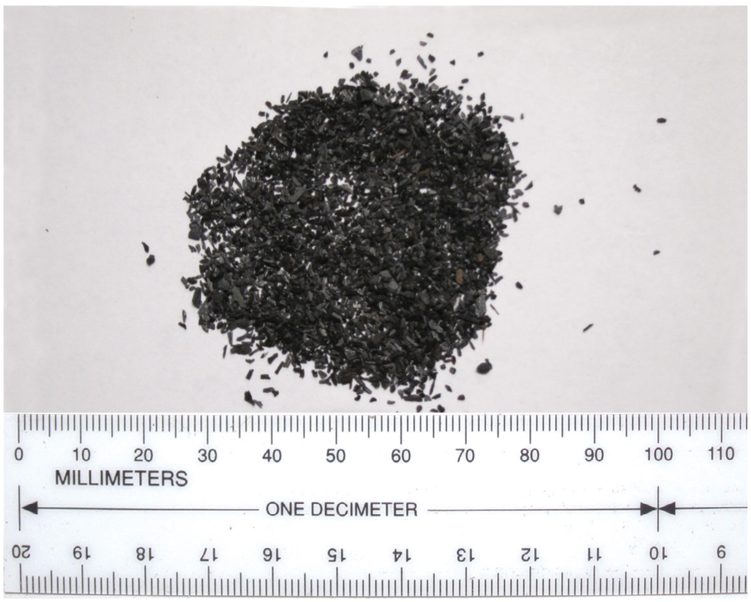
In the pyrolysis process, source materials are thermally decomposed at temperatures ranging from 500-1,000°C or 932-1,832°F in environments with little-to-no oxygen. Depending on the type of biochar desired, there can be different ways of producing biochar. For a solid, lower temperatures (392-752°F) are preferred as it helps to better retain Carbon and other nutrients. Properties, such as nutrient content, C:N ratio, and pH of the biochar are linked to the material used to produce the biochar. Table 1 lists nutrient content of an oakwood-based biochar.

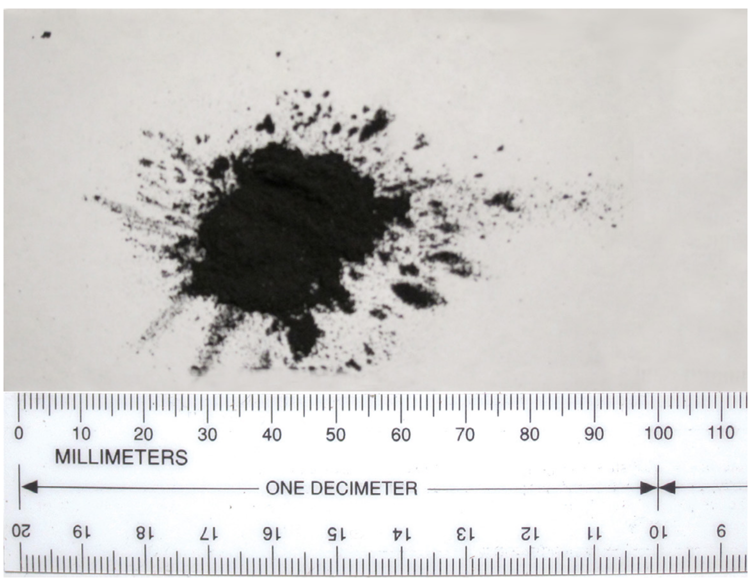
Table 1. Nutrient content (dry weight analysis) of an oakwood-based biochar.

Property	Value
C:N ratio	112:1
Total carbon	65.11%
pH	8.3%
Organic matter	58.40%
Total nitrogen	0.61%
Phosphorus	0.14%
Potassium	0.22%
Sulfur	< 0.05%
Calcium	5.01%
Magnesium	0.39%
Sodium	0.042%
Zinc	26 ppm
Iron	590 ppm
Manganese	571 ppm
Copper	< 20 ppm
Boron	< 100 ppm

Figure 1. Varied sizes of oakwood-based biochar







Biochar is available for purchase in various particle sizes (Figure 1). Particle size plays a critical role in determining the surface area and the cation exchange capacity of the finished product.

Why use biochar?

Based on some studies, the primary benefit of amending soils with biochar would be to increase nutrient retention. The higher cation exchange capacity of biochar could function as a "container" for nutrients, holding these nutrients to its surfaces. Biochar has the potential to absorb macronutrients including nitrogen and phosphorus. Research suggests there is potential to reduce fertilizer use if these nutrients are held to the surface of the biochar.

Biochar also can stimulate microbial activity, which helps microbes to break down nutrients within the soil at a faster rate. This allows plants greater access to the nutrients available. Biochar also can influence water quality by reducing nitrogen leaching into groundwater and runoff into surface water. Increased water infiltration is another occurrence with the application of biochar, as its pore space allows for aeration, and therefore, greater water infiltration in the soil.

Biochar has gained traction among scientists as a tool to sequester carbon and mitigate global warming. Studies indicate biochar can hold carbon in soils for hundreds to thousands of years as evidenced by the Terra Preta soils of the Amazonian region in northern Brazil.

Use of biochar has shown to be more effective in depleted soils. These include highly weathered and leached soils. Such soils are inherently poor in soil fertility because of several physical, chemical, and microbiological constraints that limit crop production. Therefore, biochar's nutrient retention capacity has a greater margin to increase nutrient use efficiency in such soils.

Research conducted at Iowa State University is assessing use of biochar as an amendment to soil and greenhouse soilless media. Studies so far indicate an application rate of 2,000 lbs./acre in commercial pepper and cauliflower production to positively affect soil properties, yield, and produce quality. Other commercial horticulture usage of biochar extends to orchards, vineyards, and turfgrass management. Benefits from biochar application could be based on increased yield, greater microbial activity, and reduced nutrient leaching in soil water. In commercial horticulture, biochar use is in its infancy.

Challenges to biochar use

Various source materials and pyrolysis methodologies lead to production of biochar with complex and varying properties. Biochar from one source material could behave differently than another and could react differently with two dissimilar soil types. This is a challenge as there is no uniform consensus for the use of biochar due to such a wide range of source materials and soil types. The high C:N ratio of biochar also poses a challenge in intensive crop production systems where N availability is critical for crop growth and development. Microbial mediated N immobilization can limit N availability to crops, thereby reducing crop growth and yield.

Biochar also can be expensive to apply and is not widely available to consumers and agricultural practitioners. The US Biochar Initiative has an extensive list of suppliers for commercial purchases, but stores and garden centers may not have this material available for purchase. Lack of availability, higher cost, and a long wait time to realize benefits of biochar could lead to slower acceptance and adoption. However, biochar blends are becoming more common, such as blends with compost or soilless medium. This may be a start to biochar becoming readily available in the market. Given the long residence time of biochar in the soil, its application requires a thoughtful consideration for its long-term impact on soil quality and health. Proper handling of biochar also is important. Inhaling biochar dust poses potential health problems.

Biochar research is rapidly expanding in many parts of the world. Research results on impacts of biochar on soil, crop, and climate will allow for better understanding and use of biochar. As biochar research and applications continue to develop, its role in sustainable crop production systems will continue to evolve and shape future agricultural systems.

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