PACIFIC BIOCHAR

Josiah Hunt, CEO
808-936-3484
josiah@pacificbiochar.com

Michael Fallon, CFO
805-252-8553
michael@pacificbiochar.com

The Ins and Outs of Biochar
A deep dive into the world of biochar
By Josiah Hunt

Whether created by wildfire or human hand, biochar is gaining popularity in farming and gardening because of its benefits in water and nutrient conservation, aiding microbial processes, and building stable soil organic matter. The soil fertility benefits are most pronounced on poor soils. Where soils are already highly fertile, biochar is valued for use with animal bedding, as an amendment to improve compost process, combined with fertilizers or with potting media to improve efficacy. This article dives into the essence of biochar and how it can be used for garden or farm applications.

Biochar is biomass charcoal when used for or found in soil. It is created when plant matter is transformed into charcoal while being exposed to high temperatures, with little or no oxygen. It has been a component of soil as long as fire and plants have coexisted. Biochar retains the pattern of the original plant material, but appears black. The rings of growth, the grain, the fibers, and the xylem and phloem all remain visibly intact. Charcoal carbon is stable carbon, becoming much less reactive because extreme heat creates change at a molecular level. When heated, the atoms of the plant material get very excited, begin to vibrate and dance, and at a certain point, some of the atoms break free, escaping as gases, and releasing energy as heat.

During the excited state, the remaining carbon atoms form new bonds that become increasingly more organized as temperatures rise. If oxygen is present, the excited carbon atoms will pair off with oxygen atoms, escaping to the atmosphere as carbon dioxide and other gases. If oxygen is absent until the burnt plant material cools, these new carbon bonds will remain unbroken. This change in the form of carbon at its molecular level is the key to the longevity of charcoal, which can last thousands of years in soil **(1**

To understand the values of biochar, it is best if we first understand Soil Organic Matter (SOM). The story of SOM is perhaps one of the most important sub-plots of humanity's history, because ultimately we owe our existence to quality topsoil.

We commonly measure SOM with the ‘loss on ignition’ method, which simply measures the weight of what disperses when a soil sample is burned with plenty of oxygen. There are other measuring techniques, but the end result is the same – soil analytical reports do not generally report charcoal as a distinct portion of soil, even though it does exist in soil. This creates a gap of knowledge. Fortunately, there are ways to measure unique portions of SOM that allow us to identify how much charcoal exists in a given sample. Using these methods it has been found that charcoal commonly makes up 5% to 35% of total SOM, and in some cases as much as 50% (2). Some charcoal in soil is created by humans, such as in the famous Terra Preta of the Amazon. In Iowa, however, where charcoal can make up 30% of the SOM, historical grassland wildfires are suspected as the primary creator.

The story of biochar is incomplete without mentioning our atmosphere, which is currently experiencing extraordinarily high levels of carbon dioxide and other greenhouse gases, with unnerving implications for our planet's climate. Biochar is part of the conversation around regenerative agriculture practices to restore atmospheric balances. Production of biochar from waste plant materials can become a pathway for promoting stable carbon in soil derived from the atmospheric carbon captured by plants. As plants decay, they release most of their carbon back to the atmosphere. When transformed into charcoal carbon, the decay of plant waste can be delayed for centuries, as the carbon is locked in a stable form and held in the soil rather than released to the atmosphere.

When wood is burned in a standard campfire, most all of the carbon leaves quickly as gases. But where transformation to charcoal is intentional, 20% to 40% of the original plant carbon can become fixed into stable charcoal carbon (1).

Some KEY CHARACTERISTICS OF BIOCHAR

1) **In soil, biochar can resist decay for thousands of years**, making it a long-term benefit to soil productivity. Terra Preta soils of the Amazon are the most famous example of this, where an ancient civilization created pockets of incredibly fertile soil, with charcoal as a key ingredient, within a vastness of incredibly poor soil. The fertility remains to this day. (2)

2) **Biochar has a relatively high surface area that can hold and release nutrients.** One gram of biochar can have a surface area equal to the floor of a basketball court. Charged particles (positive or negative ions) stick to the surface like drops of water stick to glass. This is referred to as its adsorption capacity, its ability to hold and release charged particles (such as plant nutrients). It is common to find charcoal in water filters and air filters because of its high capacity for adsorption.

3) **Biochar has an intricately designed porosity, determined by the plant material it was created from.** The intricate designs of tubes and tunnels that transport food and water throughout the plant body are frozen in time when carbonized into biochar.

4) **Biochar is electrically conductive.** Biochar, when created at relatively high temperatures, has conductive properties, meaning that electrons can travel across/through it with relatively little resistance, as if it was electric wiring in the soil. Nutrients are made available to plants through chemical or biological processes that involve moving electrons around. Biochar can serve as a very effective pathway for electron movement.(3).

AGRICULTURAL BENEFITS OF BIOCHAR

Water conservation. Where biochar has been applied, soils show higher water-holding capacity, increased plant-available water, increased resilience to drought, and greater crop productivity per unit of water. (4,5)

Nutrient conservation. Fertilizer efficiency and retention has been notably improved following the application of biochar. This has been primarily observed as a reduction in the loss of plant nutrients. (6,7) Plant nutrients lost to groundwater through leaching and

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to the air through volatilization, pose a huge environmental problem. The United States Environmental Protection Agency has said: “Nutrient pollution is one of America’s most widespread, costly, and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.” (8)

Facilitates microbial activity. Where biochar has been applied to soil, microbial communities are observed to be more diverse, active, and fare better through adversities such as drought. (9)

Stable SOM. Organic matter is critical for soil function and quality. Biochar is a stable form of soil organic matter that is naturally occurring and has been found to make up as much as 50% of the organic matter in soils.(2,10)

WAYS TO USE BIOCHAR ON THE FARM OR GARDEN

Biochar matures over seasons in the soil or in just weeks in a compost environment. While maturing, organic acids, minerals, soil particles, and living organisms further complicate, or change the surface of biochar, aiding in its functionality and beneficial qualities.

Adding fresh and raw biochar to soil can create a temporary nitrogen tie-up. For this reason, it is best if biochar is co-applied with composts, manures, or planting a nitrogen-fixing legume crop with it. When combined with compost piles, relatively small amounts of biochar can significantly reduce nitrogen loss during composting, and help to support thriving microbial communities. The biochar also benefits from the compost process through increased complexity of its surface area and ability to transfer nutrients.

When biochar is made, there is usually some amount of ash (non-carbon minerals) also created. Although the majority of biochar is a neutral and non-reactive carbon, ash is alkaline. Ash can be great source of plant nutrients, except nitrogen. But in alkaline soils, it must be used only sparingly. “Liming capacity” or “calcium carbonate equivalent” is the most useful measure of a biochar material’s potential pH impact on soil, as it can account for both the pH and concentration of ash in a biochar material.

Biochar works as a catalyst and unlike plant nutrients, it does not travel much. Where biochar is applied to the soil is more or less where it will stay until disturbed by soil life or human activity.

When storing biochar, keep it wet or keep it covered. Dry biochar is a nuisance to work with and can potentially become a fire hazard.

Some application rate suggestions:
(shown as % by volume unless stated otherwise)

To improve compost

- 5% to 10% biochar added at start of compost pile
- 10% to 20% when compost N is excessively high

Applied with compost
- 10% to 20% biochar to compost for regular maintenance
- 20% to 40% for major events (deep tilling, field prep, etc.)
- Allow the blend to cure for several weeks before planting if possible

Manure management (to reduce odors and nutrient loss)
- 10% of animal bedding
- Thin layer over manure lagoons
- Thin layer over fresh manure in layered compost

Planting backfill
- 10% to 20% of backfill
  A blend of biochar, compost, and minerals blended with the removed soil to achieve desired rate of regrowth.
- A few handfuls in the bottom of the hole with minerals and inoculants

Mulch layer
- 1/16” to 1/8” of biochar, sprinkle with organic fertilizer, cover completely with mulch. Repeat as desired.
- Blend biochar with mulch at 5%, add fertilizer as desired, apply in one pass. Repeat as desired.

Seed rows
- Compost and biochar blend can make a great seed blanket. Trench the line, lay the seeds, blanket with blend.
- Works best with properly aged compost/biochar blend. Rock powders and microbial inoculants are good additions.

Broad acre
- Aim for 5% to 10% by volume of cultivated topsoil
- Can be done incrementally over years
- 1/4” layer of biochar tilled into the soil 5” deep will achieve 5% by volume
- 1/4” layer of biochar covering one acre is 33 cubic yards

Potting media
- 5% to 10% by volume is common
- Lining the bottom of the pot or planting bed with biochar can be beneficial
- If ash is flushed away and nutrients are sufficiently added, biochar can be used as the sole media, as is sometimes practiced with orchids.

To amend soil during cultivation
- 5% to 10% of the topsoil
  - If cultivating to 5”, then ¼” tilled in yields 5% by volume

  4 tons per acre for vineyards and orchards
  10 tons per acre for intense row crop
  If plain biochar is used without compost or fertilizer in combination, it is best to follow amendment with a legume cover crop for nitrogen fixing.

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Definitions

- **Charcoal** - the black carbon-rich material remaining after plant matter is heated to the point of a glowing ember, and allowed to cool down before being exposed to oxygen.
- **Char** - shorthand for charcoal, often used interchangeably. Also can be used as a verb; as in to burn to charcoal.
- **Biochar** - biomass charcoal when used for or found in soil.
- **Ash** - mineral residue resulting from complete combustion.
- **Soil Organic Matter (SOM) -** once living material in some stage of decay when found in soil making up a percentage of soil composition.

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