Best Practices for Biochar-Enhanced Compost Production

Kulshan Carbon Trust, 2024

Introduction

This document provides context and research-backed best practices for producing biochar-enhanced compost within the Pacific Northwest bioregion. We aim to provide this information through the lens of biochar-enhanced compost as a regenerative natural climate solution.

What is Biochar?

Biochar is a carbon-rich solid material formed via the combustion of biomass and other carbon-containing materials under limited or no oxygen supply. Biochar production methods include pyrolysis (most commonly used), gasification, torrefaction, and hydrothermal carbonization (Enaime et al., 2020). The stability and proportion of pyrolysis products, which include char, bio-oil, and gasses, depend on the chemical composition of feedstocks (the type of biomass used for biochar production) and certain parameters used during production (Antonângelo et al., 2021). The more commonly used pyrolysis method produces a highly porous and sustainable soil amendment typically containing sixty to eighty percent (60-80%) carbon. This stable and easily managed material can be co-composted to benefit agricultural production by improving crop yield, soil health, plant fertility, water retention, and nutrient transfer. The right biochar feedstock or parent material is local, readily available, and sustainable. Feedstocks cannot be purpose-grown since that would disqualify the biochar from being eligible for carbon credits.

Inoculation

If fresh, non-inoculated biochar is added directly to the soil, it can quickly absorb many available nutrients and minerals, thus compromising early growth in young plants.Because the growth and success of agricultural plants can be determined by early-stage nutrient and water availability, biochar should be mixed with other inorganic or organic fertilizers, compost, manure, or compost tea and given time to absorb fully. This process is commonly referred to as inoculation. *The recommended minimum Inoculation period is 1 to 3 weeks* (Aller, 2024).

Biochar to Compost Ratio

Recent research suggests that a minimum of 5% biochar (1:20 biochar/compost ratio) is required to observe a positive impact on plant performance. A study by Aqasthi et al. (2017) compared a 5% to 25% range of biochar addition percentages in co-composting. The results showed that 8% to 15% biochar achieved the most success. Compost augmented by biochar will generally mature more quickly and show lower respiration rates, a higher concentration of humic substances, and a lower ratio of ammonia to nitrate than unamended compost. *In agricultural applications, a biochar loading rate from 10% to 15% is typically considered optimum* (Antonângelo et al., 2021).

Co-Composting: Why do it?

The Composting Process:

Organic Matter + O_2 + H_2O + microorganisms = Heat + H_2O + CO_2 + Humus

The value of the biochar and compost quality both improve significantly during the co-composting process. The biochar-enhanced compost (also known as co-composted biochar or COMBI) that results can improve soil health and crop yields. Optimizing the mixture and management practices of compost bolsters the conservation of nutrients, carbon, and nitrogen. As a compost additive, biochar can improve the composting and humidification processes through enhanced microbial activity and diversity. Reported benefits of biochar-enhanced compost include immobilizing toxic metals and organic pollutants, reducing nutrient losses, and mitigating greenhouse gas and ammonia emissions. Additionally, biochar addition increases the temperature during the composting process and can reduce heat loss while increasing microbial activity. *Note that moisture levels during composting should be maintained between 50 and 60% for optimum success* (Guo et al., 2020).

Biochar-Enhanced Compost Application

The available biomass, soil properties, crop types, current management practices, and goals for site use determine the application rate for biochar-enhanced compost. Lower quality, poor performing, and degraded soils typically respond more robustly to the introduction of biochar-amended compost. Other regenerative agricultural practices can also impact the optimum land application rates and frequency. When applied to nutrient-deficient and degraded soils, biochar-enhanced compost can improve yields by 16-35%. This benefit often takes two years to realize since biochar needs time in the soil to boost crop yields. (Vijay et al., 2021).

Biochar-enhanced compost (BEC) application methodology includes a liquid slurry, fertigation, top dressing, spreaders, injection, incorporation, and others as determined by the landowner. Top dressing requires a ¼” to ½” compost amendment. Production crops and cover cropping require a 1/2” to 3” compost amendment, with a typical rate of 2” or less. Containerized growing with biochar-amended soil requires a 5-25% Biochar volume, depending on crop type. For the purposes of our 2024 Biochar Scale-Up project, we have identified an application rate of 10% and 12 yards per acre of biochar as optimum, requiring a co-compost total application of 120 yards per acre. The table below serves as a reference point for our recommended application depths, rates, and consumer costs for biochar-enhanced compost during the duration of our scale-up trials.

Depth of Application (inches)	Total Co-Compost Recommended for Application (yards/acre)	Percentage of Biochar Application Rate (%)	Total Biochar (yards/acre) in recommended Application	Trial Cost (yards/Acre) of co-compost application, undelivered	Total Trial Cost of co-compost, undelivered, USD	Cost (yards/Acre) of co-compost application, delivered locally	Total Trial Cost of co-compost, delivered, USD
1/4"	33	10	3.3	17.5	577.5	22.5	742.5
1/2"	65	10	6.5	17.5	1137.5	22.5	1462.5
⅞"	120	10	12	17.5	2100	22.5	2700
1"	133	10	13.3	17.5	2327.5	22.5	2992.5
2"	270	10	27	17.5	4725	22.5	6075
3"	405	10	40.5	17.5	7087.5	22.5	9112.5

Biochar Properties for Pacific Northwest Soil Health:
Assumed Pacific Northwest soil health markers include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, sodium, pH, organic carbon, plant fertility, and moisture content.

Biochar can be applied in soils to address systemic soil health issues, creating a more complete soil ecosystem. It can increase crop yields, improve water-holding capacity, reduce runoff, and raise nutrient levels. Bottom line: its multiple uses, such as co-composted biochar application, are responsible for soil fertility enhancement and crop yield improvement, making biochar a keystone natural climate solution.

Carbon is essential to soil health by helping prevent erosion and providing essential functions, such as soil water storage, fertility, and microbial activity. Typical soil organic matter content is between 0.5 to 5% by mass. (Trippe, 2022). Soils with organic matter content higher than 10% are referred to as organic soils, as their properties are dominated by organic matter rather than mineral content. Soils with a history of tillage often have lower organic matter content than uncultivated or reduced-tillage soils. Growers can increase soil organic matter by leaving plant residues, applying compost, biochar, or other types of organic matter, and by reducing tillage. However, excessive organic matter content can challenge crop growth unless mineral amendments balance the high organic matter content of the soil (Trippe, 2022). When properly applied as a soil amendment, biochar-enhanced compost can increase crop productivity, compared to fertilizer alone. It can also improve overall plant health, alleviate the effects of drought, and mitigate salinity stressors. However, it is important to note that fully fertile soils may only benefit from biochar application if properly balanced with other soil nutrients.

Biochar as a Natural Climate Solution
Ten percent of greenhouse gas emissions in the Pacific Northwest are attributed to agriculture, and carbon dioxide (CO_2) makes up more than three-quarters of greenhouse gas emissions globally (Krull, 2019).

Plants capture and sequester atmospheric carbon (CO_2) while growing. Soils are the largest terrestrial reservoir of organic carbon (Vijay et al., 2021). When plants die and start to decompose, they release this carbon back into the environment. When introduced into the soil environment, biochar can stockpile much of this carbon instead. Biochar offers the additional benefit of soil enhancement, making it a powerhouse sustainable agriculture practice.

Soil amendment produced by co-composting with biochar is a valuable method of restoring degraded land and reducing greenhouse gas emissions from agricultural fields. One pound of biochar has the capacity to sequester 2.93 pounds of CO_2 from the atmosphere, a process referred to as negative priming (Krull, 2019). Production of biochar as a method of waste management also sequesters atmospheric carbon by converting biodegradable carbon (biomass) into aromatic carbon (biochar), which can last for centuries in soils. Proper biochar application in agricultural soils has the ability to offset 12% of regional CO_2 emissions. It also supports other regenerative practices such as cover cropping, green mulching, no-till, and grazing rotations (Krull, 2019). Since carbon sequestration is enhanced by producing and applying co-compost to the soil, its use contributes to mitigating global climate change. Moreover, biochar's porous nature effectively retains moisture in the soil to build climate resilience against increasingly common floods and droughts.

Biochar is also considered a beneficial fertilizer and conditioner to manage soils contaminated with toxic materials and restore soil fertility. Heavy metals in soil are stabilized due to the characteristics of biochar, which ultimately reduces metal uptake by plant roots and improves crop health, soil nutrients, and organic matter. The leachable acidic or alkaline compounds in biochar modify the pH of the immediate environment, which can favor healthy microbial activity (Antonângelo et al., 2021).

Communities and individuals can promote resilience and sustainability by managing resources in a future-friendly manner that accounts for conservation and climate change. Research has shown that biochar-enhanced compost helps land stewards adapt to climate change by stockpiling soil carbon. Therefore, we recommend carefully applying biochar-enhanced compost using best practices as an effective regenerative natural climate solution.

About Kulshan Carbon Trust

Kulshan Carbon Trust is a non-profit organization that serves Northwest Washington landholders and aims to accelerate the local adoption of natural climate solutions that revitalize rural economies, regenerate the land, reduce emissions and sequester carbon. To date, KCT has focused on regenerative agriculture practices, climate science, producing biochar from residual biomass and applying biochar on forests and farms in Whatcom, Skagit and Island counties in partnership with local organizations and supporters. To learn more, visit us at our website: www.kulshancarbontrust.org.

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