US BIOCHAR INITIATIVE BIOCHAR-US.ORG

BEYOND APPLICATION:
LEARNING MORE ABOUT BIOCHAR

Biochar incorporation to existing ornamentals. *Photo by Mina Vescera*

How biochar impacts soil health

These are general ways biochar impacts soil. Results vary depending upon the soil type, biochar type, plant nutrient requirements and other environmental factors.

Increases:

- Soil moisture
- Plant available water
- Water use efficiency
- Microbial activity
- Hydraulic conductivity
- pH
- Cation or anion exchange capacity
- Soil organic carbon
- Soil aggregation
- Soil porosity
- Nutrient uptake
- Soil microbial biomass C and N
- SOM and its stability

Decreases:

- Nutrient leaching
- N volatilization
- GHG emissions
- Soil bulk density
- Compaction
- Leaching of pollutants

ASSISTANCE APPLYING BIOCHAR

Several tools are available to help farmers make biochar application decisions in order to provide the most positive impacts for crop yields and soil properties. In addition, financial assistance to qualifying farmers and ranchers may be available from the USDA-NRCS (CSP, EQIP and RCPP programs).

Online Tools and Technical Assistance

Dynamic response to biochar tool

The Web Soil Survey, a comprehensive online soil database and toolkit, is hosted by the USDA-NRCS. Within that suite of tools, the "Dynamic Soil Properties Response to Biochar" function rates the potential for an improvement in one or more soil properties leading to better crop growth following a biochar application to different soil types.

https://websoilsurvey.nrcs.usda.gov/app
Once an area of interest (AOI) has been selected, under the 'soil data explorer' tab → 'suitabilities and limitations for use' tab → 'soil health' section → 'Dynamic Soil Properties Response to Biochar' subsection.

The "Dynamic Soil Properties Response to Biochar" tool should be used for an initial screening that farmers can use to get an idea of the potential impact of biochar on soil health and crop growth. It assumes a corn stover or manure-based biochar with a mid-range particle size. It also assumes minimal incorporation with tillage or spreading the biochar on the surface with a manure spreader.

This tool uses SURRGO data sets that take the inherent properties of the soil series to predict outcomes making assumptions about the native pH, cation exchange capacity, organic matter levels and other measurements obtained from the soil survey. It does not factor in current soil properties, which are affected by management practices like liming, soil amendments and fertilizer applications. So, this tool may not be able to precisely predict farm-field level outcomes.

Biochar Atlas decision support tool

This online, interactive biochar decision support tool guides biochar selection for specific crops based on soil characteristics and biochar properties. It allows users to match the right biochar with the right resource deficiency. The tool uses the inherent properties of a biochar, based on feedstock and production conditions to address crop nutrient requirements and site-specific soil deficiencies.

Photo by Matt Krumenauer

Though it was originally developed for Pacific Northwest farmers, the Biochar Atlas can be used for any soil. Efforts to expand the Atlas across the US are underway.

pnwbiochar.org/tools → click 'Biochar Selection Tool' → click 'Get Started' → follow the steps to view recommendation.

Financial Assistance

Conservation Practice Standard 336

In 2019, the USDA-NRCS introduced the Soil Carbon Amendment as an interim Conservation Practice Standard. The standard was designed to promote the use of amendments derived from plant or animal residues to improve the physical, chemical, and biological properties of the soil. In 2022, the Soil Carbon Amendment was included in the National Handbook of Conservation Practices under Code 336. It has yet to be adopted by all states.

Under this standard, biochar is considered a soil amendment, and farmers may receive financial assistance to apply it. Farmers should check with their local NRCS office to see if the program is available in their state and if they qualify for assistance.

CASE HISTORY: FOUR WINDS FARM

Improving soil drainage

CHALLENGE/OPPORTUNITY: In Homestead, IA, Four Winds Farm owners, Scott and Megan, grow hemp, medicinal herbs and flowers. The soils are high in clay, poorly drained, with low CEC and organic matter. They use cover crops, crop rotations, and soil amendments (compost, compost teas, mulch and warm castings) to build healthy soils on their farm. A few years ago they also began applying biochar.

SOLUTION/APPROACH: In Spring 2020, they mixed 16 yards of a miscanthus biochar with approximately 200 yards of compost. They then broadcast spread it over their hemp fields using a backhoe. In 2021, they had access to a silage wagon and purchased three more yards of biochar, mixed it with 30 yards of compost and, using the auger conveyer system, were able to apply the biochar blend directly into the planting rows. Access to this piece of equipment allowed them to move from tilling the entire field to strip tillage.

In addition to field applications, Scott and Megan use biochar in container plantings. In large pots, they incorporate biochar, rock dust, worm castings and compost mixture at 50% by volume into the potting mix. For soil plugs, they use a similar mixture at a lower rate of 25% by volume.

Biochar applied to a rye cover crop prior to terminating and planting corn (Spring 2023). *Photo by Julia Cavicchi*

RESULTS: While no yield data is available and other amendments were also applied, Scott says that adding biochar has definitely increased soil organic matter levels across the farm. The cation exchange capacity and drainage issues also improved since they began using biochar. The farm still has issues with a plow pan at 6", but the plants are overall very healthy and external fertilizer inputs are now negligible.

Biochar loaded into a manure spreader in Lincoln, NE. *Photo by Ann Powers*

FERTILIZER/LIMING VALUE OF BIOCHARS

Fertilizer

Nutrients are required by plants in different quantities for growth and development. The nutrient content of biochars is influenced by feedstock type and pyrolysis conditions. Nutrient availability to plants is related to chemical properties of the nutrients, biochar and soil types. Hence, the nutrient content of manure/waste biochar is higher than biochar made from crop residues or woody biomass.[1]

By knowing the fertilizer value of a biochar, farmers can adjust their crop NPK requirements accordingly, including the use of other nutrient sources to meet crop needs.

Liming value

Soil acidity can be a major constraint to plant growth. To ameliorate acidic soils, agricultural liming materials (calcitic or dolomitic lime) are used to raise soil pH to optimal levels for crop growth (~pH 6-7 for most crops).

The inorganic constituents of the ash fraction of biochars are composed of carbonates, silicates, phosphates, sulfates, chlorides, and hydroxides.[2] Some biochars with high amounts of these inorganic compounds can have a high liming value and be used in place of or in concert with agricultural lime to raise soil pH.[3]

CASE HISTORY: PORCH VIEW FARM

Producing small-batch biochar from wood waste

CHALLENGE/OPPORTUNITY: Porch View Farm is a family-run 22-acre operation in Woodbine, MD. Owner Keith Ohlinger incorporates soil health principles into his silvopasture operation to produce fruits and nuts and support livestock like Irish Dexter cattle, pigs and sheep. Thinning and pruning some 10,000 trees creates a substantial amount of wood waste that Keith recycles into his soil.

SOLUTION/APPROACH: After learning about the Amazon's Terra Preta de Indio soils in 2013, Keith started making biochar. The wood waste biochar is produced in a ring kiln (3ft. diameter, 1ft. tall) by continuously adding new wood on top of actively burning wood. Once it is converted to charcoal it is quenched with water until no longer steaming. Keith typically burns 5-6 front loader buckets full of wood to produce 1 front loader bucket full (about 1 cubic yard) of biochar. The whole process takes about 4 hours. The resulting biochar is combined with manure and bedding and left to compost for 3 months before being applied to the field.

Photo by Kim Slezak

The biochar: compost mixture (1:10-15 ratio v/v) is applied twice per year using a 400 lb. capacity tow-behind spinner spreader. Keith relies on the farm's earthworm and dung beetle populations to incorporate the material into the soil profile.

RESULTS: While Keith has not quantified the impacts of using biochar on his farm, he is happy with the health of his forages and animals and is saving money by eliminating the use of synthetic fertilizer. He sees earthworms thriving in the soil with over 25 per square foot, suggesting high organic matter levels and biological activity. He plans to continue making and applying biochar to his fields. His advice is to start small, experiment and seek out reliable information.

See compost fact sheet: go.unl.edu/biochar.

CASE HISTORY: OASIS VINEYARDS

Increasing water use efficiency

CHALLENGE/OPPORTUNITY: Oasis Vineyard, managed by Monterey Pacific, Inc., is located near King City, CA in the Salinas Valley. The soils are sandy and irrigation needs are high. Like much of California in recent years, the vineyard has experienced prolonged drought periods, and the owners wanted to see if biochar could save water and not adversely impact grape quality.

SOLUTION/APPROACH: In 2016, an 8-acre biochar field trial was established to evaluate how biochar and compost treatments impact soil water potential, vine growth and harvest yields. Treatments included a control (no compost, no biochar), compost (15 tons compost, no biochar), biochar (no compost, 10 tons biochar) and biochar and compost (15 tons compost, 10 tons biochar). Each ½ acre plot (4 rows of 121 vines) was replicated four times. The biochar cost $200/ton and was purchased from Pacific Biochar Benefit Corporation. The amendment treatments were trenched directly into the prepared planting row prior to planting Pinot Noir vines.

RESULTS: The first three years[9] of the trial found significant increases in yield, with the biochar treatment resulting in more than 40% increase over the control. The compost and biochar treatments only produced an average of more than 30% yield increase over the control. Compared to compost alone, biochar plus compost treatments improved water use efficiency, vine growth and harvest yields (number of clusters). Biochar treatments showed no adverse impacts on wine quality as quantified by grape sugar content, color and flavor.

A 2019 progress report[10] showed that the return on investment from adding the biochar was paid off with increased yields at the first harvest (additional revenue of $2,600/acre in the first two producing years), with higher profit expected for the life of the vines. Doug Beck, project leader, stated "One of the drawbacks of biochar is that it's really expensive," noting that applications have run about $2,000 per acre for the biochar alone at the rate of 10 tons per acre. "But, if the lifespan of the product and its benefits are long-term, it can be worth it if one application provides benefits over 20 years of a vineyard's life."

BIOCHAR PERSISTENCE IN SOILS

The atomic ratios of hydrogen to organic carbon (H/C_{org}) or oxygen to organic carbon (O/C_{org}) predict biochar mineralization rate or stability in soils over time.[4]

As pyrolysis temperature increases, the H/C_{org} and O/C_{org} ratios decrease, thus the persistence of carbon in the biochar increases.[5] Additionally, biochar impacts the native soil organic carbon pools leading to a decrease in organic matter mineralization over the long-term.[6]

Biochars' impact on soil carbon cycling has implications for climate mitigation and adaptation, carbon markets, and future carbon credits that may impact farmers.

See carbon fact sheet:
https://biochar-us.org/welcome-biochar-learning-center

FARMERS' BARRIERS TO ADOPTION

Numerous benefits associated with using biochar as a soil amendment have been identified, yet barriers to adoption remain. Farmer surveys and discussions identify multiple barriers to adoption of biochar: lack of trusted relevant information, lack of funding, disconnect between farmers and resources, biochar diversity and site specificity, minimal awareness and access to information, need for more research, cost vs. economic benefits, availability and the need for technical assistance and decision support tools.[7,8]

These barriers to adoption are decreasing as our ability to predict interactions between biochar and soil evolves and more information is disseminated. Meanwhile, the biochar industry continues to grow, in order to provide biochar that meets the needs of local farmers and agricultural service providers.

Additional resources

- **USBI biochar learning center** biochar-us.org/welcome-biochar-learning-center
- **New York Soil Health biochar page** newyorksoilhealth.org/resources/biochar
- **Pacific Northwest biochar atlas** pnwbiochar.org
- **University of Nebraska biochar fact sheets** go.unl.edu/biochar

Biochar being broadcast applied in southwest Iowa. *Photo by David Laird*

Reference Guide

1 Hossain, M.Z., Bahar, M.M., Sarkar, B. Donne, S.W., Ok, Y.S., Palansooriya, K.N., Kirkham, MB., Chowdhury, S., and Bolan, N. 2020. Biochar and its importance on nutrient dynamics in soil and plant. Biochar 2, 379–420. https://doi.org/10.1007/s42773-020-00065-z

2 Singh, B., Singh, B. P. and Cowie, A. L. 2010. Characterisation and evaluation of biochars for their application as a soil amendment. Australian Journal of Soil Research. 48, 516–525. DOI: 10.1071/SR10058

3 Domingues R.R., Trugilho, P.F, Silva, C.A., Melo, I.C., Melo L.C.A., Magriotis ZM, et al. 2017. Properties of biochar derived from wood and high nutrient biomasses with the aim of agronomic and environmental benefits. PLOS ONE 12(5): e0176884. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0176884

4 Spokas, K. A. 2010. Review of the stability of biochar in soils: predictability of O:C molar ratios. Carbon Manage. 1, 289–303. https://www.ars.usda.gov/ARSUserFiles/41695/cmt.10.32_spokas.pdf

5 Lehmann, J., Cowie, A., Masiello, C.A. Kammann, C., Woolf, D., Amonette, J.E., Cayuela, M.L., Camps-Arbestain, M., and Whitman, T. 2021. Biochar in climate change mitigation. Nat. Geosci. 14, 883–892. https://doi.org/10.1038/s41561-021-00852-8

6 Ding, F., Van Zwieten, L., Zhang, W., Weng, Z., Shi, S., Wang, J., and Meng, J. 2018. A meta-analysis and critical evaluation of influencing factors on soil carbon priming following biochar amendment. Journal of Soils and Sediments, 18(4), 1507–1517. https://doi.org/10.1007/s11368-017-1899-6

7 Sherman, C.D. 2022. Biochar: Practices, Perspectives, and Prospects in New York State Agriculture State. University of New York at Albany ProQuest Dissertations Publishing. 29161672

8 Seman-Varner, R., Hassebrook, C., Zilberman, D., Brown, R., Paul, B., Winstel, L., Odom, L., Moebius-Clune, B., Laird, D. and Amonette, J.E. 2022. Scaling Sustainable Biochar Research & Commercialization for Agriculture & Conservation Benefits: A Summary from a Stakeholder Convening [White paper]. Washington, DC: AFT-FFAR-NCAT

9 https://pacificbiochar.com/wp-content/uploads/Final-Oasis-Vineyard-Biochar-Field-Trial-Science-Report-2.pdf

10 https://napagreen.org/wp-content/uploads/2021/01/Monterey-Pacific-Vineyard-Management_Biochar-Trial.pdf

Suggested citation: Aller, D., Trippe, K., Smith, B., Seman-Varner, R., Baschieri, R., Delaney, M., Miles, T. 2023. Beyond Application: Learning More About Biochar. Biochar assistance, persistence, and barriers to adoption. United States Biochar Initiative

For more information, please visit US Biochar Initiative: **biochar-us.org**

Additional resources can be found under the 'Education' tab

Scan to visit US Biochar Initiative Learning Center

Published by: USBI in partnership with Nebraska Forest Service.
Thanks to the US Forest Service for funding support.