Biochar Factsheet

Benefits

Applications in Horticulture & Agriculture

- Increases water use efficiency. Higher absorption versus perlite & vermiculite.
- Replaces peat moss as a sustainable option.
- Holds nutrients & stabilizes both sandy & clay soils. Evidence of higher crop yields & healthier, greener turf.
- Augments compost nutrient/nitrogen values, accelerates compost process & reduces odors, even at percentages as low as 5-10%.
- Sequesters carbon for 100 to thousands of years, qualifying for carbon credits.

What is Biochar?

Ancient Soil Regeneration Meets Modern Technology

Biochar is a highly porous, stable, carbon-rich material that is produced by thermochemically decomposing organic feedstock in the absence of oxygen. It's important to note that no burning or combustion takes place because of the absence of oxygen, meaning that a high percentage of the carbon in the biomass is converted to a soil-stable form. Once incorporated into the soil, carbon is stored and removed from the carbon cycle.

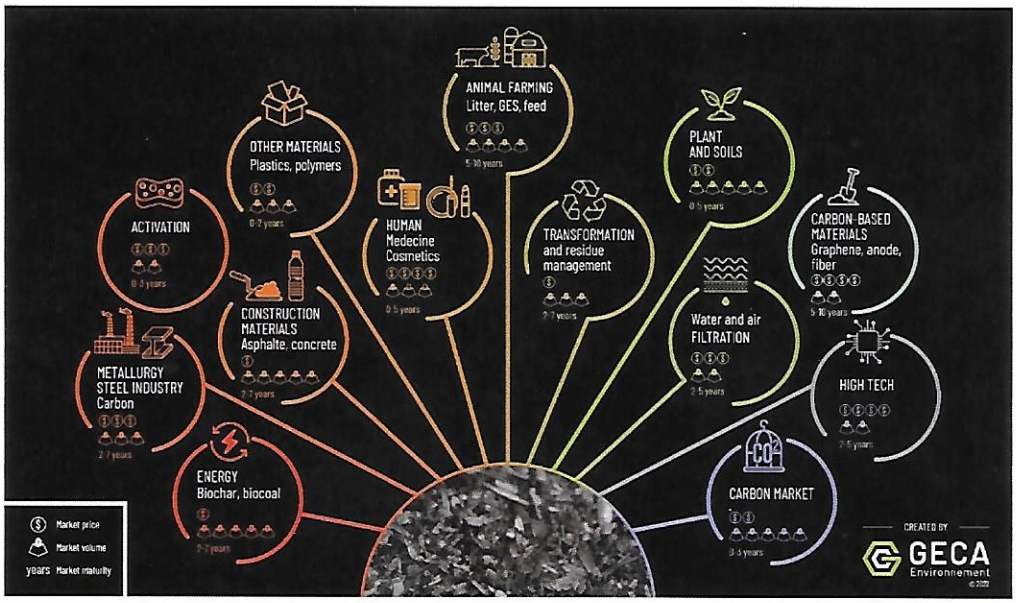
The use of biochar in agricultural applications dates back thousands of years. Solid archaeological evidence supports its use in the thriving agrarian Brazilian Amazon region—to amend the previously nutrient-poor soil— over 2000 years ago.

When the feedstock used in the biochar production process is a clean blend, such as that derived from New England forestry operations, the quality of the biochar is also very high. As a soil amendment, biochar has been found to increase microbial activity and decrease water requirements across a wide range of soil and compost types.

Market Segments & Applications

As public awareness of biochar and its benefits grows, inventors are rapidly identifying and testing new biochar applications, from building and construction materials to land/water remediation and pharmaceutical products. If biochar—and its carbon–is expected to be sequestered for at least 100 years—as in road construction, pond remediation, and agriculture, credits for the sequestered carbon can be sold on voluntary carbon markets, where current demand for biochar-backed credits outstrips supply.

For horticultural and agricultural applications, discerning buyers are willing to pay a premium for biochar with third-party-verified PH/ash composition and surface area, produced from clean forestry feedstocks.



Outlook: Horticulture & Agriculture

Biochar is increasingly seen as a valuable soil amendment, particularly in areas of drought and poor soil conditions. Worldwide shortages and transportation costs for perlite and vermiculite, combined with a growing awareness of the environmental impact of peat moss harvesting, have all made biochar more attractive as an alternative, driving demand for additional field research and new “designer” blends.

Global demand for biochar has been growing exponentially over the past several years, and the United States is beginning to exhibit similar growth. Biochar is a carbon-negative product that can be produced and delivered locally, offering sustainable alternatives to incineration, reducing air and water pollution, and contributing to the circular economy.

Properties

Biochar Made from Clean New England Wood Chips

- Feedstock is a mix of New England hardwoods & softwoods.
- Biochar particle size & other properties can be customized to fit a variety of applications.
- Biochar has proven its effectiveness as a soil amendment across a wide range of feedstocks, crops, climates, and soil conditions around the world.
- State-of-the-art machinery ensures a clean, carbon-negative process.

Quonset Soil Solutions
www.qssbiochar.com

BIOCHAR INCREASES PLANT SURVIVAL

Concerns about the high cost of growing media, recent supply chain issues, and unease about the environmental impacts of peat have spurred interest in alternative media for the horticultural and turf industries. Biochar offers the potential of a natural, local, and sustainably sourced alternative to peat and other common growing ingredients including vermiculite and perlite. Research shows that certain types of biochar can be a cost-effective replacement for growing media and potting additives like perlite[1], clay granules, Sphagnum peat[2], and vermiculite. Studies using biochar on greenhouse plants such as lettuce, sunflowers, and marigolds resulted in equal or better performance. In one study involving tree seedlings, wood biochar effectively replaced peat with varying results based on the form of biochar[3] (powder, pelletized, or bulk).

Biochar from different feedstocks and temperature regimes behaves differently depending on the applications. Research has shown that some types of wood biochar can effectively replace peat[4]. However, biochar particle size, total extractable nutrients and pH levels make a difference. Biochar made from bark has a different nutrient content than biochar made from leaves and branches. In general, care should be taken to sift out the fine fraction (<1 mm) and conduct a pH and nutrient analysis before using the material as a growing media.

The core attributes of biochar as a replacement for existing growing media (be it horticulture, green roofs, or golf course turf) are:

1. **Bulking agent: medium size (2 mm to 6 mm).**
2. **Hydrophilic: ability to retain moisture**
3. **Low in nutrients like NPK**

Economic benefits

- **Increase plant survival:** Increase plant survival: Certain types of biochar have shown an increase in water holding capacity when used as an amendment in soil mixes[5]. With increasing swings in climate, biochar medias can provide plants with more available water which can reduce their mortality.
- **Boost in yields:** Biochar amended soil mixes boost yields in certain crops and conditions, particularly in sandy soils during hot summers. Increases in yields were shown in studies of blueberries[6] and in lab tests of wheat, barley, and maize[7].
- **Carbon credit markets:** Biochar has been shown to be valued in the carbon market (see our other fact sheet on "biochar and carbon markets" for details). Adding biochar to soil media, or compost or directly to soil can generate carbon benefits.

  Currently, voluntary carbon buyers are paying about $200 per ton, for the carbon benefits of biochar. Using biochar can be a potential new source of revenue for greenhouse operators and soil mixing businesses.

How to use biochar in growing medias

As many have said, "Not all biochar is created the same." In general, biochar specification varies by crop and media requirements.

Given all these variables, potential users of biochar or those that are selling biochar as a growing media should consult with their local biochar producer or their local horticulturalist at a nearby university.

Nursery crop	Existing problem/challenge	General specification	Desirable biochar qualities
Tree seedlings	Hold onto H_2O. Out plantings can dry out	1/4" in size (3 mesh)	Hyrdrophylic. Help outplanting survival in summer heat.
Green roof media	Heavy soil media. Metal runoff	3/4" in size and up. Bulky	Lightweight. Ability to absorb metal runoff
Flowers and veggies	Peat replacement. Boost yields	1/4" in size (3 mesh)	Hold H_2O. Higher yields
Golf greens and turf	H_2O is expensive	Powder for spraying as a slurry	Hydrophyllic. Reduce irrigation costs. Boost turf health

CASE HISTORY: MISSOURI ORGANIC RECYCLING

CHALLENGE/OPPORTUNITY: Founded in 1992, Missouri Organic Recycling provides soil blends and compost products to their customers. Since 2008, they've diverted more than 150 million pounds of food waste from landfills and turned them into valuable compost products for farmers and growers in the region.

Stan Slaughter, an Education and Garden Specialist for Missouri Organic Recycling (based in Kansas City, MO), specializes in creating value-added soil blends using low-value ingredients (food waste, leaves, urban tree cuttings, and other waste biomass) and converting them into high-value organic soil amendments.

In 2019, Stan heard about biochar as a promising soil organic matter additive that could sequester carbon and provide a more nutrient rich soil product. He was particularly interested in biochar's ability to act as a "condominium to hold onto nutrients and water" compared to compost.

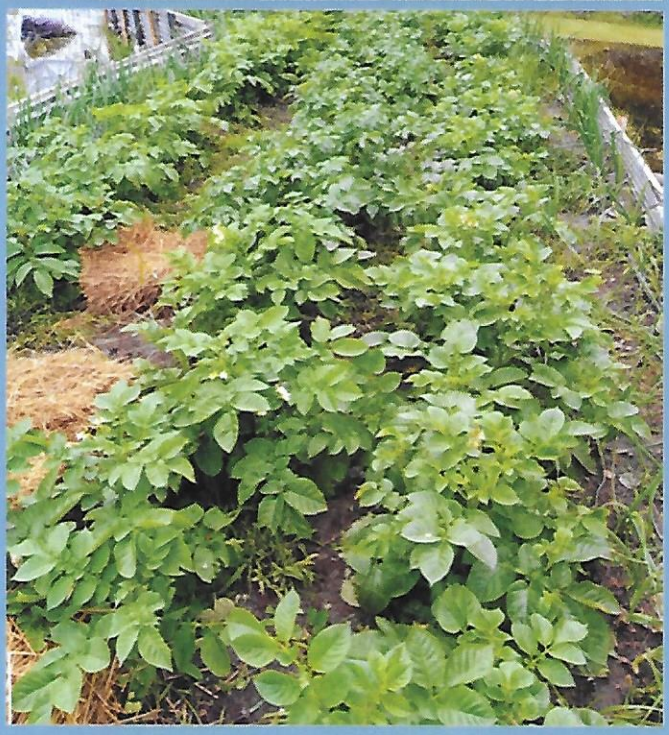
SOLUTION/APPROACH: To explore biochar as a potential soil blend ingredient, Stan worked with Dave Yarrow and Phil Bloom and ran different tests of biochar amended soil blends. After a couple of years of testing and development, Missouri Organic Recycling began using biochar as an amendment in their compost and soil

blend products, creating a new biochar-based product called "Green Frontier Compost."

RESULTS: The company notes that customers like the biochar-amended products for two main reasons: the biochar increases soil moisture helping new plants survive in the summer heat and it increases yields. One customer said of the biochar product, "We are proud to have it on our shelves. As our customer base expands into more diverse growing needs, we find that it fits the bill for whatever they are growing."

CONCLUSION: Missouri Organic Recycling anticipates growth in their biochar product lines as they increase the supply of high quality biochar ingredients. Regarding biochar supplies, Stan said "The biochar market is decent. We have enough demand to move a truckload of biochar today, but I need better supply volumes to grow the market. Then, we can turn the demand for biochar into a flood".

CASE HISTORY: DR. BRYAN MANN, VICTORY GARDENS



CHALLENGE/OPPORTUNITY: Dr. Bryan Mann owns and operates a small specialty crop vegetable farm near Maiz, Kansas. His company, named "Victory Gardens," symbolizes his passion for sustainable farming. Since starting his business in the late 2000's, Mann has grown nutrient dense produce with a minimal carbon footprint.

"We spend a lot of time trying to build our soil out here. If you have healthy soil, you are far less likely to have to use chemicals and other inputs from unsustainable sources (petroleum-based products)," Mann said. "I believe in sustainable farming. I truly do. It is the future of agriculture. We can't keep cultivating farmland with fertilizers and chemicals."

In addition, Mann said "with climate change impacts increasing, we are seeing longer, drier summers that really stress crops. My biochar and compost amended beds can hold onto moisture, and I've shown that I can still produce quality tomatoes even in very hot summers."

"Specialty crop vegetable farms are in a unique position to have a collective influence on carbon sequestration in the USA," he continued. "Over 74,000 vegetable farms exist in the USA and account for approximately 4 million acres." (add reference)

SOLUTION/APPROACH: Many of Kansas' soils are dry and heavy in clay. Mann found that by using different composting techniques and Hugel tunnels combined with biochar, he can grow high quality crops on his farm, including nutrient dense crops even during summer drought conditions.

Mann has been using biochar for about the last 10 years. He makes his biochar with different scrap wood and other feedstocks from around his farm. He adds biochar as a layer to the top of Hugel beds until the top is completely covered with biochar.

RESULTS: Mann grows his crops with all natural ingredients, and do not include any fertilizers or herbicides. His margins for growing specialty crops are good compared to other farmers in the region.

CONCLUSION: Demand for high quality produce remains strong and sales increase every year. Mann's commitment to sustainable and regenerative techniques are important to his customers. With the impacts of hot dry summers increasing, using biochar provides a welcome way to mitigate extreme weather events and avoid crop losses.

Non-economic benefits

Made from a variety of biogenic biomass sources (leaves, wood chips, agricultural residues, orchard pruning, vineyard cuttings, and many others), biochar feedstocks are natural and renewable.

Many locations across the United States have excess biomass with little or no market value. These materials are often either burned or sent to a landfill. Biochar applications like in soil blends and amendments provide a valuable mechanism to divert large-scale waste biomass resources and make them into something that can increase crop survival and yields.

CASE HISTORY: NORTH SHORE COUNTRY CLUB

Challenge/Opportunity: Dan Dinelli, CGCS, golf course superintendent at North Shore Country Club, wanted to find a product to replace peat in the rootzone on the greens. He chose to use biochar, because it sequesters carbon and stays intact for hundreds of years, while a high percent of peat will degrade. This benefits the long-term function and sustainability of a putting green.

Solution/Approach: Biochar was pretreated with nutrients, bio-stimulants, carbon sources, and pH modifiers and then set aside to allow for the amendments to absorb. It was also inoculated with microorganisms, stored in a dark, warm room, and stirred periodically. The biochar for each treatment was mixed with USGA recommended rootzone sand at a ratio of 9:1 to represent a rootzone that was 90% sand 10% biochar V/V. The sand/biochar mixes were then packed into PVC cylinders at a 12" depth on top of 4" of pea gravel to simulate a USGA recommended rootzone for a green. The turf was watered and cut two to three times a week and fertilized once.

Results: On his course, Dinelli found that quality, pre-conditioned biochar added value in several areas:

- **Water retention**
- **Nutrient holding due to biochar's high CEC**
- **Soil and plant health was enhanced through microbial activity**

Conclusion: Dinelli is very pleased with the sand/biochar he uses and believes other golf courses would see similar results. Yet, he cautions that more research is needed to set standards that would allow other courses to replicate his results without doing the studies that he did.

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BIOCHAR IN COMPOST

Improve compost and save money

Adding biochar activates the composting process by enhancing the activity of microorganisms, which raises the temperature, reduces composting time and speeds up stabilization of the compost.[1]

Research shows that that adding 5% to 10% by volume biochar at the start of the compost process can generate the following benefits:

- **Speed up the composting process by 20% through better aeration of the pile and increasing microbial activity[5]**
- **Capture odors[6]**
- **Generate a compost with higher nutrient because biochar retains nitrogen[7]**

The use of biochar during the compost process yields a product comparable to those obtained with mineral fertilizer additions with a lower environmental impact.[2]

More recently, researchers found that benefits of co-composting with biochar far outweighed any drawbacks or side-effects when compared with other amendments. The quality of biochar-compost improves soil health and can boost crop yields.[3]

How to use biochar in the composting process

To use biochar in the composting process, the material should be added just like any other composting ingredient using existing equipment.

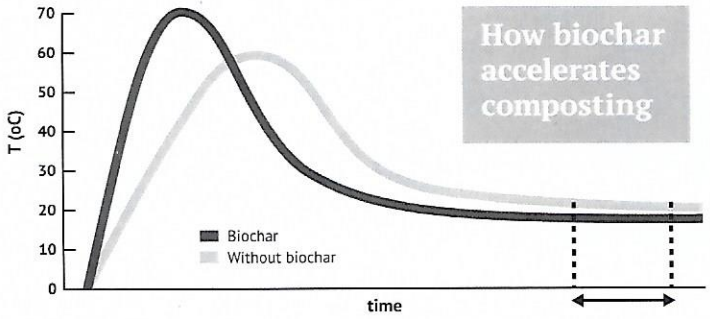
The scientific literature and experience of composters indicates that the best ratio of biochar to compost is in the range of 5% to 10% by volume. Adding more than 20% or 30% is not recommended as an excessive amount can interfere with biodegradation.[4]

Compost operators will realize these benefits

- **Accelerates compost process**
- **Reduces nutrient losses**
- **Reduces greenhouse gas emissions**
- **Acts as a bulking agent**
- **Increases microbial activity**
- **Reduces odor**

Economics

Increased production and savings: Composters who use biochar often see processing time reduced. More importantly, they report cost savings from turning piles less frequently. The fuel and labor savings is even more appealing than reducing compost time.



Biochar increases the temperature in the compost process, accelerating material decomposition

CASE HISTORY: REXIUS

CHALLENGE/OPPORTUNITY: Jack Hoeck is VP of Environmental Services at Rexius, a family-owned compost and soil producer in Oregon. Jack heard about the benefits of biochar through his conversations with John Miedema of BioLogical Carbon. He was intrigued by the material as a possible new amendment to help the company produce better compost.

SOLUTION/APPROACH: Rexius started out by creating two compost windrows, one with biochar and one without. In the windrow with 5% biochar by volume added, the compost-biochar had more moisture, nitrates and other nutrients than the pile without biochar. Overall, the quality was better in the biochar windrow.

RESULTS: Since starting to use biochar in the compost process, Rexius has continued to record higher nutrient values in their biochar-compost than compost without biochar. They also report higher beneficial plant bacteria and microbes compared to compost without biochar. Both the higher nutrients and more beneficial microbes create a higher value soil product that commands a better price for their home gardening potting and garden soils product lines.

Jordan Launch of Rexius said there are multiple benefits from incorporating biochar in their composting process. The two main ones are the labor and fuel savings from not having to turn the compost pile as often. That's in addition to having a higher value product at the end of the process. Biochar helps stabilize the soil whereas compost alone can degrade relatively quickly. Investing in adding biochar and biochar compost to soil offers long term benefits.

CONCLUSION: As Jordan mentioned, "The better your soil, the more productive your garden will be (whether that is better tomatoes, more colorful and vibrant flowers, or higher yields of lettuce or kale). Biochar and biochar-compost helps improve soil. Though the material costs more, it results in greater yields and makes it well worth the investment."

CASE HISTORY: PACIFIC BIOCHAR

CHALLENGE/OPPORTUNITY: The Oasis Vineyard located outside of King City, CA. was interested in trying different amendments to study how biochar and compost treatments effect soil water use, soil health, vine growth, harvest yields and grape quality.

The Oasis Vineyard had soils with low organic matter. In addition, the vineyard needed to conserve more water. Because biochar and compost can build soil organic matter and help retain moisture, the vineyard wanted to use them in a field trial.

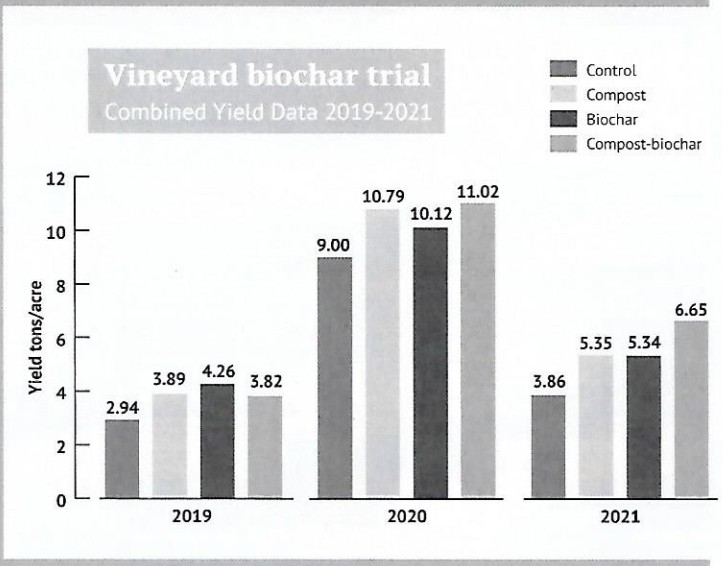
SOLUTION/APPROACH: Starting in 2016, the Sonoma Ecology Center, UC Riverside and Pacific Biochar worked with the Oasis Vineyard manager Monterey Pacific Inc. to develop a multi-year field trial with funding from the California Department of Water Resources. Treatments included biochar only, compost only, biochar-compost, and a control (no amendment).

New plantings of vines were prepared by ripping rows in the soil to a 30 inch depth, 2 feet wide by 2.5 feet deep (approximately 25 cubic feet of soil per vine). Biochar was applied in the planting row at 10 tons per acre wet weight, and compost was applied at 15 tons per acre wet weight.

RESULTS

Some of the reported findings include:

- The highest yield came from the biochar-compost treatment resulting in a 45% increase over the control.
- Increased pruning weight was observed for both the compost and the compost + biochar treatment. Higher cluster counts were observed for both the biochar and the compost + biochar treatments.
- All treatments received the same irrigation regimen throughout the trial, demonstrating improved water use efficiency where soil had been amended.



CONCLUSION: Results from the field research trial indicate that biochar and compost treatments can improve water use efficiency, vine growth, harvest yields and soil health for vineyards newly planted on low organic matter sandy soil.

The vineyard manager, Monterey Pacific, said the return on investment for adding biochar paid off in the first grape harvest with higher profit expected over the life of the vines.[8]

(Economics continued)

Higher quality material: Increased nitrogen in the final product gives biochar-compost a better nutrient profile than compost alone, making for a better soil amendment.

Interested in learning more about the economics of biochar? See the Biochar Atlas-Cost Benefit Analysis tool, which guides users to assess whether biochar is a good investment for your soil. pnwbiochar.org/tools/cba

Non-economic benefits

Biochar is made from a variety of biogenic biomass sources (leaves, wood chips, agricultural residues, orchard pruning, vineyard cuttings, and many others). As a biogenic resource, biochar feedstocks are natural and renewable.

Many locations across the United States have excess biomass with little or no market value. These materials are often either burned or sent to a landfill. Compost companies provide a valuable mechanism to divert large-scale waste

biomass resources and make them into something that can help improve soils. Biochar is a new product made from low-value material that can help add value to compost.

In so many communities, excess biomass shows up at landfills for disposal. Every fall, when the leaves drop, the level of waste biomass that gets sent to the landfill is disturbing. This is also true for the debris from a strong windstorm or ice storm event. If we can develop new markets for low-value biomass (like biochar), we are helping to create natural, renewable, locally produced material that can benefit people and the environment.

Some tips for using biochar

- **Biochar compost products can be spread using the same type of equipment farmers use to spread compost.** It can either be worked into the soil using a plow or side-casting along rows, as in the case of biochar-compost vineyard applications
- **The amount of biochar-compost that you should apply to your soil will depend on a variety of factors**
- **To learn more about how biochar can help your soil, please view the Biochar Atlas** pnwbiochar.org/tools
- **The Biochar Selector tool can guide you on the amount of biochar for your soil.** pnwbiochar.org/tools/selector

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