Delving into Biochar

By Scott Jamieson

This is the second of two articles on biochar, a potent soil amendment for urban and suburban landscapes.

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Google "biochar" and you'll get nearly one million results. In the past few years, biochar has taken the landscape industry by storm. It is a new term for a carbon-rich soil enhancement that is a type of charcoal made from plant waste. (See "Biochar: A Game-Changer for Soils," in the January 2013 issue for more background information.)

Why all the excitement about biochar? It's a natural material that makes agricultural land more fertile (it was first used by the ancients centuries ago) and shows great promise for landscape trees and shrubs. It helps retain soil moisture, reducing the need for watering. It persists in the soil for years, reducing or eliminating the need for re-application. It even has the potential to help offset climate change since it holds carbon in the soil indefinitely, preventing it from escaping into the atmosphere and contributing to the greenhouse effect.

Biochar, the darkest streak above, with compost and soil for use in a simulated tree pit at the Bartlett Tree Research Laboratories in Charlotte, NC. Photo: Bartlett Tree Experts

Tree research beginning

In some ways, the excitement over biochar has made it seem larger than life. This enthusiasm is supported by extensive research into biochar's effects on agricultural soils and crops. But, there has not been such research looking at biochar with urban and suburban soils, and trees and shrubs.

That is until a few years ago, when scientists at the Bartlett Tree Research Laboratories and The Morton Arboretum (with financial support in part from the TREE Fund) began conducting the first studies investigating biochar's impact on landscape plants. Partnering on some of the projects and working independently on others, they want to find out if biochar can improve the interactions of roots and soil in the compacted soils typical of urban and

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suburban areas.

The research, which involves well over a dozen studies, looks at biochar as a mulch, soil amendment and as backfill, and includes greenhouse, nursery, field plot and street settings.

Promising findings

The upshot of the findings so far is that biochar can have a measurable positive impact on soil quality and plant growth. So much so that Bartlett Tree Experts now makes it available in an organic form, certified by the Organic Materials Review Institute, for use on client properties.

Root growth of honey locust seedlings growing in compacted soil after 18 months of no treatment (left) and an application of biochar top-dressing (right). Photo: Morton Arboretum Soil Science Laboratory

Highlights of the research findings to date:

Biochar works best in combination with compost. While applying biochar alone is beneficial in the long term, applying it in combination with compost yields the best short-term results. Dr. Kelby Fite, principal biochar investigator for the Bartlett Tree Research Laboratories, explains: "Biochar itself does not provide nutrition or moisture. But it has all this ability to adsorb – or take up – other substances. So you could say it needs to be charged up with these substances first. When you mix organic matter like compost with biochar, you're charging the biochar with nutrients and water. It can then make them available to plants.

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"Another analogy is that biochar is like a sponge, just waiting to soak up material," he says. Adding compost is equal to pre-wetting the sponge. Unless you pre-wet, or pre-charge, the biochar 'sponge,' it will actually draw nutrients and water out of the soil at first, which could mean negative short-term results for plants. But once the biochar sponge is wet, or you could say its hunger is satisfied, microbes and moisture flow in and out of it. It becomes part of the soil continuum.

"So to see short-term benefits, blend biochar with compost," Dr. Fite recommends.

He notes that, while fertilizer can also be a nutrient source to charge biochar for short-term results, the organic matter of compost provides the microbial activity and nutrient cycling that fertilizer does not. "Fertilizer does not recreate a forest soil, like compost can," Dr. Fite explains. "But it still plays an important role in soil management. For instance, we at Bartlett incorporate prescription fertilizer along with compost and biochar when we want to improve soil conditions and structure using our root invigoration process."

• A synergy exists between compost and biochar. Not only does combining compost with biochar improve biochar's performance, blending the two also makes compost more effective. When biochar and compost are combined, trees and shrubs show greater growth and performance than with either of the two amendments alone.

• More is not necessarily better. Often with soil amendments, if one lump is good, two lumps are better. It is especially true with compost. However, the principal does not apply with biochar. More is not necessarily better; in fact, it can be worse. The research shows that a little bit goes a long way, which certainly has an added cost benefit. The sweet spot, says Dr. Fite, appears to be five percent biochar by volume, though he wants to find out if even less can be effective.

• Moisture retention. In simulated tree pits at the Bartlett lab in Charlotte, NC, soils with biochar had higher levels of soil moisture throughout the last growing season than those without it. While Charlotte did not experience the severe drought that the Midwest had, the Southeast did see drought conditions. Despite the drought, the researchers did not provide supplemental water to the study pits.

The increase in soil moisture was statistically significant, but it is too early in the multiyear study to tell if it is biologically significant for the trees.

• Disease resistance. In greenhouse studies by Bartlett scientist Dr. Drew Zwart, while conducting research at the University of Washington, seedlings growing in soil with biochar have shown significantly improved resistance to phytophthora canker, whose causal agent can also cause

In a greenhouse trial, (left to right) no treatment, biochar alone, compost alone, one type of biochar blended with compost, another type of biochar blended with compost. The biochars blended with compost resulted in the best growth. Photo: Bartlett Tree Experts

root decay. Tree seedlings of two species potted in soil with biochar had less extensive cankering from the disease. Along several measures, the plants growing in biochar performed equally to plants that were chemically treated with standard products.

Of particular interest is the fact that the experiment was conducted in such a way that there was no physical contact between the phytophthora organism and the soil.

While the results are promising, it is too early to tell if similar results will occur with landscape trees.

• Increased plant growth. In an 18-month nursery study, Dr. Bryant Scharenbroch, soil scientist at The Morton Arboretum, found significantly more root growth in honey locust seedlings planted in soil that had biochar top-dressing as compared to honey locust seedlings growing in soil treated simply with water. He is also investigating biochar's effect on turf and seeing similar results.

"Compared to our controls, he says "we are finding increases in soil organic matter content and tree and turf growth, with biochar applied as a top-dressing in a variety of soil types and across multiple species."

Dr. Scharenbroch has also begun investigating the economics of using biochar, compared to other treatments. He looked at the total cost of applying the materials, including the material itself, labor, transportation, equipment and other costs, across treatments of water, mulch, compost, fertilizer, aerated compost tea, commercial biological products, biochar and biosolids to achieve comparable increases in plant growth. From lowest to highest costs, biochar ranked fifth among the eight treatments. Biosolids and mulch were the least expensive, while aerated compost tea and commercial biological products were the most expensive.

Regarding the cost of biochar, Dr. Scharenbroch observes, "These are all short-term studies," pointing out that, while compost can provide more organic matter in the short term, biochar can potentially improve soil quality for a longer period.

"This also does not consider the side benefits – the money you save when you're not producing fertilizers off site, the potentially reduced need for fertilizers, the environmental benefits of diverting the plant waste that is used to make biochar from landfills, and the climate benefits of long-term carbon storage," he says.

• Multiple growing seasons. Compared to agricultural research, investigations involving woody plants require a longer time frame to see significant plant response, which usually means multiple growing seasons. Though plant response in these studies has not taken longer than the scientists

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Researchers from The Morton Arboretum and Bartlett Tree Experts drill into a tree pit on Chicago's Milwaukee Avenue and fill the holes with biochar in a street tree study. Photo: Bartlett Tree Experts

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expected, it certainly has taken longer than they would like.

Looking ahead

One big question looking ahead is whether biochar could be a component of structural soils, or tree pit mix. "With tree pits, the idea is to grow big trees in small spaces," says Dr. Fite. "But you have soil volume that's entombed by concrete, so not only is there limited room for roots to grow, but there is no nutrient recycling. Could biochar be an organic component of those soils?"

Bartlett and the Arboretum are conducting one study that is an early first step in trying to answer that question. It looks at 60 street trees in tree pits along Milwaukee Avenue in Chicago's bustling Wicker Park/Bucktown communities. As with most tree pits, the trees are impacted by limited root space, soil compaction,

limited water and drainage, poor soil structure and nutrient availability, and pavement de-icing salts.

The researchers have amended the soil of some of the trees with biochar, others with biochar plus fertilizer, and still others with fertilizer alone to see if they can improve the conditions in this stressful growing environment.

The hope is that biochar could help give urban street trees a lifespan of more than the typical seven years. Time will tell.

The Milwaukee Avenue street tree research attracted much media attention, with coverage by ABC7 Chicago TV, WBBM Newsradio, WGN-AM and Chicago Public Radio. Photo: Bartlett Tree Experts

The bottom line

"The take-home on biochar right now," says Dr. Scharenbroch, "is that we're seeing some positive responses in growth with it. We're seeing some improvements in organic matter and soil properties with char." He notes that not all biochars will have the same impact. "What the different improvements are and what the magnitude will be, we just don't know yet."

Scott Jamieson is Vice President of Corporate Partnerships and National Recruiting for Bartlett Tree Experts. Local offices are in Northbrook, Lake Barrington, Bolingbrook and Chicago.