Biochar for Arborists

On Arbor Day 2012, the State of Delaware and Bartlett Tree Experts decompacted and amended the soil with compost and biochar to help invigorate the roots of an historic copper beech tree using air-tool excavation and mixing. Photo courtesy of Bartlett Tree Experts.

By Kelpie Wilson

Has your community caught the buzz around biochar? Word about this ancient yet new soil amendment has been traveling at Twitter-speed around the country as gardeners, farmers and plant lovers of all types learn of the intriguing properties of charcoal added to soil. That is what biochar is – charcoal made from biomass that is clean and safe to use in soil.

For four years now, tree care industry professionals have been learning how to use biochar to solve some common problems: low organic matter in disturbed soils, soil compaction, soil water retention and nutrient leaching. This article will give you some background on what biochar is and how tree care professionals are developing applications for it.

What it biochar?

Scientists first became aware of biochar after studying the properties of carbon-rich soils created by the original inhabitants of the Amazon who added charcoal to soils along with food waste and other nutrients. Five hundred years after the demise of the cultures that created them, the terra preta soils (Portuguese for "dark earth") are still five times more productive than adjacent, un-amended tropical soils. The longevity of the effect comes from the high stability of charcoal in soil. It takes hundreds to thousands of years to break down, forming a kind of semi-permanent compost.

Premium Landscape Biochar is a new soil amendment offered by Bartlett Tree Experts, which promotes it as a long-lasting additive that is ideal for trees and shrubs on both urban and suburban properties.

Today, agronomists (experts in soil management and field-crop production) at institutions such as Cornell and Iowa State are deeply engaged in probing the secrets of biochar's effects on soil. Fused carbon rings form the microstructure of biochar; while at coarser scales a highly porous carbon matrix structure emerges that has robust ion-exchange properties. This structure supports soil fungal and bacterial life while holding water and nutrients. Plant roots love it, and with proper nutrient support, plants of all kinds, including trees, seem to thrive in biochar.

Biochar is produced by baking biomass without the oxygen that would cause it to ignite and burn. Baking wood and other plant materials releases a flammable gas that yields energy. That is the basic biochar-making process, but the end product is not a single, well-defined substance. Depending on the

Auguring holes for biochar applications to street trees in Bucktown, Chicago, Illinois. Courtesy of Bryant Scharenbroch/Morton Arboretum Soil Science (www.masslaboratory.org).

feedstock and processing conditions (time and temperature), different biochars can have very different properties. The International Biochar Initiative, an organization formed by leading biochar scientists, recently issued Biochar Standards for reporting characteristics of biochar such as pH and carbon stability to help guide the selection of biochar materials for specific soil and plant requirements.

Biochar and trees – research

Trees are a particular focus of biochar research in Japan, which also has an ancient tradition of charcoal use in soils. Professional arborists there apply biochar in root-zone trenches to revive much-loved ancient trees on the grounds of temples and shrines that suffer from ground compaction caused by visitors. Before application, the biochar is inoculated with mycorrhizal fungi and nutrients. Research shows that biochar increases the abundance of mycorrhizal fungi in soil, and inoculated biochar has become a popular ingredient in nursery media for increased tree seedling survival and growth.

In the U.S., biochar research has begun to move out of universities and government labs and into the hands of professional farmers, horticulturalists and arborists. Leading the way in tree care is Bartlett Tree Experts, an accredited TCIA-member company that began an ambitious biochar research and development program four years ago at the Bartlett Tree Research Lab and Arboretum in Charlotte, North Carolina. Researcher Kelby Fite, Ph.D., heads the program of field and greenhouse trials for Bartlett. "We wanted to find out if biochar could improve root-soil interactions in compacted urban soils," Fite says. "The objective was to replace short-lived compost with a longer lasting source of soil carbon."

Dr. Fite found that his first experiments were inconclusive. His team applied several different biochar formulations to established trees, but delivery rates were "a stab in the dark" and no differences could be determined over a single growing season. Greenhouse work was more telling. They found clear improvements using biochar amendments, particularly in sandy soils where biochar's water holding capacity is a big boost.

Nutrient management is important as well, and one clear result is that blending biochar with compost provides a real synergy of short-term nutrient support from the compost while the longer-term benefits of biochar develop. In all kinds of agronomic conditions, researchers have found that it can take several years for biochar to accumulate nutrients and boost soil life. Often the greatest effects are not seen until the second or third year after biochar application. For long-lived species such as trees, this feature of biochar is an important benefit with the potential to reduce care and maintenance needs over the long term.

Participants at the 2010 International Biochar Conference in Brazil observe a stunted orchard growing on poor tropical soils while standing in an adjacent grove of 50-foot tall orange trees growing on ancient terra preta soils. Local farmers will pay five or six times more for land with terra preta soils, an indication of the increased productivity value. Credit: Gloria Flora.

TREE Fund grant

Bartlett has also teamed up with others for an industry-wide approach to the investigation of biochar.

In 2010, Dr. Bryant Scharenbroch of The Morton Arboretum Soil Science Laboratory and Dr. Fite won a TREE Fund grant to examine biochar for urban tree care. The grant has funded three real world experiments with street trees.

Soil auguring and filling of holes with a biochar is one of three applications methods being tested. Courtesy of Bryant Scharenbroch/Morton Arboretum Soil Science (www.masslaboratory.org).

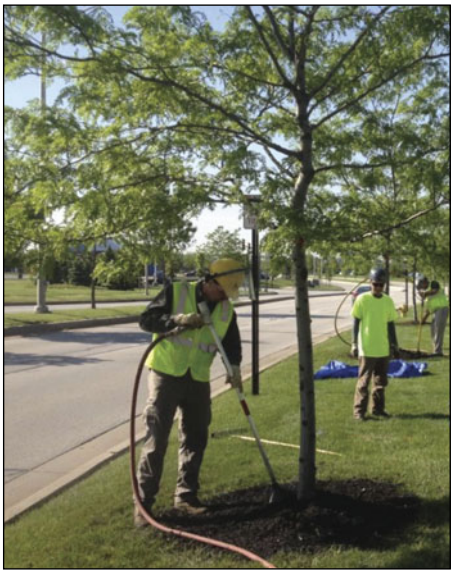
Root growth of Gleditisia triacanthos *after 18 months of no treatment (left) compared to biochar application (right) of 2 cm top-dressing. Trees were grown for 18 months in a compacted (1.8 Mg m-3) B horizon soil. Courtesy of Bryant Scharenbroch/Morton Arboretum Soil Science (www.masslaboratory.org).*

One study in Bucktown-Wicker Park neighborhood of Chicago includes 54 trees in sidewalk cutouts with treatments being augured into the soil. An experiment in the City of Bolingbrook, Illinois, has 75 trees with treatments being applied with air-injection tools. An additional landscape experiment is planned to begin late this fall in Aurora, Illinois, using liquid injections of biochar. All three experiments include different combinations of biochar and fertilizers, and also non-treated controls. Soil and tree health measurements taken last fall, just months after the applications, have as expected shown no impacts. The landscape experiments are in their infancy, and monitoring will continue throughout the next three to four growing seasons.

Dr. Scharenbroch says, "landscape experiments are important, but can be challenging due to the inherent site variability, so much so, that treatment effects can be masked by soil heterogeneity (or variation) on site. In addition, trees are long-lived organisms and, as such, can be slow to respond to experimental treatments."

Experiments in nurseries and greenhouses with younger trees and herbaceous plants allow for more experimental control and faster plant responses. These experiments are also being conducted at The Morton Arboretum, and have been showing positive responses in soil quality and tree health with biochar.

"Compared to our controls," says Scharenbroch, "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 (e.g., sand, non-compacted silt loam, and compacted clay loams) and across multiple tree



Biochar applications to street trees in Bolingbrook, Illinois. Courtesy of Bryant Scharenbroch/Morton Arboretum Soil Science (www.masslaboratory.org)

genera (e.g., *Gleditisia, Acer, Malus, Betula*, and *Tilia*). (See images above.)

In their experiments, Drs. Fite and Scharenbroch have discovered that biochar quality matters. Improvements in plant growth tend to be greatest with biochars with lower carbon-to-nitrogen ratios. Biochar from a now defunct supplier turned out to be not as good as the current supply from Biochar Solutions, a woodchip biochar producer based in Pueblo, Colorado. Now that he has a supply of consistent, quality biochar, Dr. Fite can begin to refine his biochar-nutrient formulations to produce "designer" biochar amendments targeted to specific soils and conditions, such as drought resistance for sandy soils.

Economical and effective application methods are important and these researchers are focusing on three alternatives: soil auguring and filling of holes with a biochar; air-tool excavation and mixing biochar into soil with physical decompaction; and liquid injection of fine biochar/water slurries using existing fertigation (application of fertilizers, soil amendments or other water-soluble products through an irrigation system) technologies. Fite said that the liquid injection method looks promising although he is dealing with challenges around plugged injectors and keeping the finely ground biochar in suspension.

Fite and Scharenbroch are also working on application rates. Fite says, "we did not see any detrimental effects from application rate until we reached 20 percent biochar by volume – a rate that is not even possible in the field." Fite has found a "sweet spot" at around 5 percent and is now looking at even lower rates to determine if there are measurable benefits from using even less of the somewhat expensive product. The price of pure biochar seems to hover around $1 a pound.

The TREE Fund seed grant runs out next year, but Drs. Scharenbroch and Fite will continue the biochar research through other funding sources, institutional support, and volunteer efforts. The Morton Arboretum has an active citizen science program that provides many enthusiastic student interns and other volunteers to help with experiments. One thing Scharenbroch would like to try is to make biochar from biosolids for a higher nutrient product. As the research matures and results come in, they will be publishing in scientific and popular journals. Many of these projects are currently being presented at industry conferences, including TCI EXPO this fall.

Biochar and special tree problems

Bartlett has also started to look at the role that biochar could play in mitigating common tree diseases. Lab employee Drew Zwart, who is now completing a doctorate program at the University of Washington, was interested in the contribution of biochar to disease resistance. Biochar research on vegetable plants found that biochar-amended plants seemed to develop a systemic resistance to disease.

Zwart inoculated a number of gardenia shrubs with the phytopthera that causes sudden oak death (SOD). He inoculated

The gardenias and vinca in the foreground plot are planted in soil that was not amended at all, whereas those in the plot behind them were planted in soil treated with biochar and compost amendments. Courtesy Kelby Fite/Bartlett Tree Experts.

the above-ground stems only, while applying the biochar to the soil root zone, theorizing that any disease resistance would be due to increased plant vigor, not a direct effect of biochar on the pathogens. His results show that the biochar-amended plants showed just as much stem-canker size reduction as gardenias treated with the commercial systemic fungicide Agri-fos. Biochar-treated gardenias also exhibited less water stress than untreated plants.

Another tree care issue that biochar could address is the impact of DuPont Imprelis. The now-banned herbicide has killed woody plants in many areas where it was applied and tree care professionals are being asked how to save affected trees and prevent the long-lived chemical from doing more damage. The University of Minnesota Extension recommends the use of activated charcoal in new plantings to bind any residual Imprelis in the soil and keep it from being taken up by plant roots. The strongly adsorptive properties of activated charcoal make it a commonly used remedy for cleaning up all kinds of soil and water contamination.

Biochar is not activated carbon, but it does have some similar characteristics, including large surface area that is chemically active. Biochar is commonly less than half the price of activated charcoal and it could be a viable tool for mitigating the effects of Imprelis – certainly it is a worthy research topic. Those who are interested in investigating this should be aware that some biochars will be much more effective as adsorbents than others. The International Biochar Initiative Biochar Standards provide standardized tests that measure the surface area and porosity of biochar.

How to use biochar

By now you have probably gotten the impression that biochar is a pretty complex subject. Fortunately, the research community and companies such as Bartlett are working hard to bring forth solid applications. Bartlett feels the hard work is justified. Kelby Fite says, "We are early adopters, but we feel it is worth it for the long term results." And enough results are in now that Bartlett is starting to use biochar in commercial applications – they have applied 100 cubic yards of biochar so far in 2012. Customers are interested because even though the upfront costs are greater, they look forward to a payback of less water and fertilizer use over time.

Given the variables in biochar materials and compounds, tree care professionals can provide substantial value to customers who want to try biochar in their tree plantings by following the research and development of biochar and learning about successful applications.

A few resources to help you get started:

The International Biochar Initiative (http://www.biochar-international.org/) has a number of resources including a bibliography, research summaries, application guidelines and Biochar Standards. The IBI is rolling out a Biochar Certification program soon that will help buyers know what they are getting.

The Morton Arboretum (www.mortonarb.org) has several different biochar research trials in place and will soon communicate results in publications and presentations.

Bartlett Tree Experts (www.bartlett.com/index.cfm) has biochar application information on its website and is interested in sharing results with the industry as a whole.

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