RENOVATION TECHNIQUES and TOOLS for SOIL DECOMPACTION

Biochar being incorporated into existing soil with a pneumatic air tool. Photos courtesy of the author, unless otherwise specified.

By Kelby Fite, Ph.D.

We've all seen them – victims of urban soil. Trees placed in cut, filled, mixed, contaminated and compacted soils, expected to live and thrive yet struggling merely to survive. What happens to them? More important, is there anything we can do?

Roots perform many functions for the tree, including anchoring the tree, absorbing water and nutrients, storing carbohydrates and producing chemicals and hormones. When you think about this, you realize you may have taken them for granted. Arborists' minds often are most concerned with larger diameter, woody roots; however, the real workers for the health of the tree are fine roots. These are the 1mm-or-so-in-diameter feeder roots that absorb the majority of water and nutrients. Not only that, but it is the youngest of these fine roots that are most efficient at this uptake. These are the white, fleshy, fuzzy roots you find digging in soils as they warm in spring.

The urban-soil environment, however, is a tough one for these roots. Low levels of organic matter and mineral nutrients coupled with high levels of compaction result in a poor environment for root growth. Physical compaction of the soil not only makes it difficult for roots to grow, but also exacerbates drought and flooding because of inadequate pore-space distribution. Everywhere you look in the urban landscape, you will find some level of soil compaction. Current development and construction processes pay little to no attention to these factors and often cause severe damage to existing roots and future soil volumes for root growth.

Many attempts have been made to alleviate the stresses this soil environment places on trees' roots. Techniques such as vertical mulching and radial trenching have been explored. Both of these treatments involve using an auger (vertical mulching) or trencher (radial trenching) to create vertical channels through the compacted soils. Once these holes or trenches are made, they are backfilled with an improved soil to promote root growth. The few studies that exist on these types of treatments show that root response is generally limited to the local areas that were improved and not beyond. Does that mean they don't work? No, but there should be limited expectations for tree response. These methods often are preferred when remediating a perched water table due to deeper compacted layers from construction or agricultural plow layers. Radial

trenching and/or vertical mulching open up vertical channels, which are necessary to move water down through the soil profile.

A variety of pneumatic decompaction devices have been developed to physically break up compacted soils beneath landscape trees. Such equipment is designed to fracture compacted soil layers by introducing pressurized air or nitrogen. The resulting fractures often are filled by fertilizer, amendments and/or water. Research with these devices has shown that improvements in soil compaction are limited to locations near the fractures in heavy soils but may have some temporary improvements in sandy soils. Results show that treatment of moderately compacted clay-loam soils with these types of equipment has no effect on root length, mass or diameter.

The development of supersonic air tools has revolutionized the arboriculture industry and greatly increased efficiency when completing tasks such as excavating a buried root collar. These tools can be used to channel high-pressure air into the soil, loosening and tilling it in a manner akin to traditional mechanical tillage, but without causing significant damage to the root system. Bartlett's Root Invigoration Program was designed to use these tools to rehabilitate urban soils and improve tree performance. The first step in this process uses the compressed-air excavation tool to till the soil and break up the compaction in the upper soil layer, where the majority of fine feeder roots are located. Then, organic matter and prescription fertilizer amendments are added to the loosened soil and homogenized with the air tool. Finally, the treated area is mulched and watered to prevent drying and settle the soil.

For several years, we tested the effects of Root Invigoration and its individual components (mulch, fertilizer and air-tool tillage) on declining red maple trees (*Acer rubrum*) at four urban sites in the eastern United States (Anderson, South Carolina; Myrtle Beach, S.C.; Boston, Massachusetts; and Pittsburgh, Pennsylvania). Our goal was two-fold: 1) to document the effects of Root Invigoration and 2) to establish whether any single component of the process gives results similar to the comprehensive program.

Soil decompaction occurring underneath the dripline.

Fifty trees at each site received either Root Invigoration, mulch only, granular fertilizer only, air tillage only or no treatment. The sites represented a range of "real-world" urban environments: a golf course, a college campus, a civic-center parking lot and an urban roadside planting. Treatments were applied between August 2005 and February 2006, and the results were monitored through November 2007. The details of this project were reported in the September 2009 issue of *Tree Care Industry Magazine*, if you would like more information, but the general overview will be provided here.

Soil strength, nutrient content, organic-matter levels and volumetric moisture were all improved with Root Invigoration. None of the individual treatments could match these responses, although in some cases they improved a single parameter.

Across all sites, Root Invigoration reduced the soil's resistance to root penetration ("soil strength") for two seasons following treatment, whereas mulch and air tillage only reduced soil strength for one season. Decreased soil strength means that roots can more easily penetrate soils and exist in a soil environment that is more conducive to water, nutrient and oxygen exchange. This result stresses the importance of both organic amendments and an appropriate mulch layer when rehabilitating poor soils.

The soil's organic-matter content was increased by both mulching and Root Invigoration. Organic matter in urban soils is a major source of energy for soil organisms that contribute to an overall healthy soil environment; its breakdown releases essential nutrients and improves soil structure.

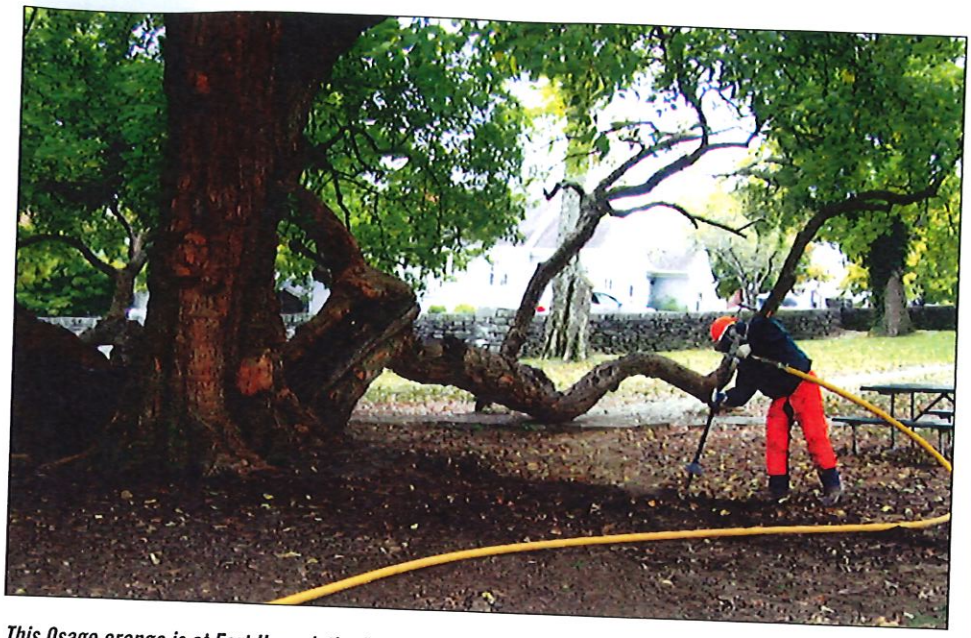
Soil moisture, measured only at the Anderson site, was higher in mulched soils (Root Invigoration and mulch only) than in unmulched (air tillage only, fertilizer only and controls). So, if you are managing soil that is otherwise conducive for root growth and function but suffers from low moisture levels, mulch can be an effective, low-cost solution.

In the years since this original research was conducted, additional research into soil amendments has been conducted revealing the potential of biochar as an additional soil amendment. Biochar is a new term for the ancient practice of converting agricultural waste into a stable, carbon-rich

Many construction projects don't consider soil or tree preservation, which often necessitates soil remediation programs.

charcoal for soil enhancement (*terra preta*, dark earth). Research has shown increases in root and shoot biomass with biochar amendments. Biochar has been shown to improve soil fertility and quality over time when added to existing soils. This material is known to alter the physical and chemical properties of the soil around the root rhizosphere and buffers fluctuations in soil moisture and nutrient levels. It also alters the biological dynamics of a soil through several methods.

Biochar is initially sterile and therefore has no indigenous populations of microorganisms. Instead, the physical structure of the biochar encourages colonization by various mycorrhizal fungi, nematodes and bacteria. Research has shown beneficial microorganisms, such as Trichoderma, are increased in soils amended with biochar. These microorganisms play a role in eliciting a response in plants, which can result in the increase in defense mechanisms within the plant that prevent damage from insect pests and disease and can help the



This Osage orange is at Fort Harrod, the first established fort in Kentucky, and was planted by a settler, making it probably the first tree planted in Kentucky. It is highly visited and receives much compaction by foot traffic. It is mulched and decompacted every few years. Photo by David Leonard, from the TCI Magazine *archives.*

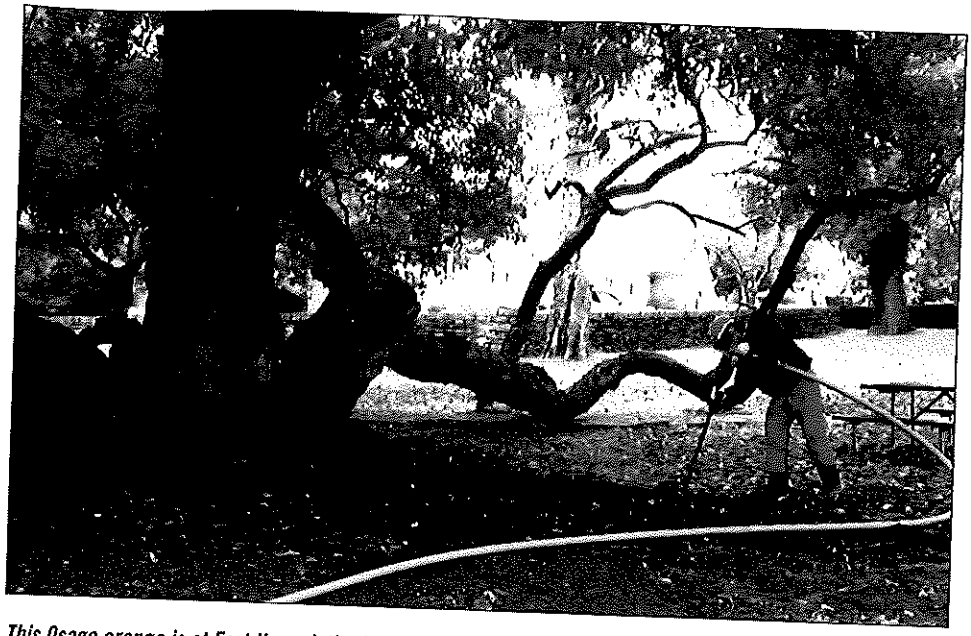
plant with abiotic stresses. This response from biochar additions has been documented for several foliar and stem diseases as well as mite infestations.

Biochar rates are critical and can be detrimental if applied at too high a rate. More research is required to tease out the nuances among species and soils; however, most research with woody plants indicates that a 5% rate by soil volume (1:20 ratio) appears to be the best rate. Most of the research occurring with biochar is in agronomic crops and not woody plants and trees. There is certainly a need to investigate any potential benefits of blending biochar with other soil-amendment products beyond compost.

Conclusion

Unfortunately, the urban environment is dominated by conditions that inhibit optimum tree performance. This is a result of the development techniques that pay little regard to current or future tree performance. The good news in this is that there are techniques that have been shown to improve the soil conditions and allow for increased root performance on these compromised sites.

Kelby Fite, Ph.D., is a vice president/director at Bartlett Tree Experts' Bartlett Tree Research Lab in Charlotte, North Carolina. This article was based on his presentation on the same subject at TCI EXPO in Charlotte, N.C., last fall. To listen to an audio recording of that presentation, go to this page in the digital version of this issue online, under the Publications tab, and click here.



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