Impacts of Aerated Compost Tea on Containerized *Acer saccharum* and *Quercus macrocarpa* Saplings and Soil Properties in Sand, Uncompacted Loam, and Compact Loam Soils

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Abstract. Aerated compost teas (ACTs) are applied to soils with the intent of improving microbial properties and nutrient availability and stimulating plant growth. Anecdotal accounts of ACT for these purposes far outnumber controlled, replicated, and peer-reviewed experiments that have examined the impacts of ACT on soil properties and plant growth responses. This research assessed the impacts of four rates of ACT compared with water on containerized *Acer saccharum* and *Quercus macrocarpa* saplings growing in loam, compacted loam, and sandy soils. No significant differences were found comparing water with ACT applied at rates of 2, 4, and 40 kL ACT/ha for any of the six tree responses and 21 soil responses. Microbial biomass nitrogen (N) and potassium (K) increased, and available N decreased, in soils treated with ACT at 400 kL·ha$^{-1}$ compared with water. Shoot, root, total biomass, and the root/shoot ratio were significantly greater for *Quercus macrocarpa* trees growing in compact loam with the 400 kL·ACT/ha treatment compared with water, but significant differences were not detected for this application rate compared with water in the other soil types and in no instances with *Acer saccharum* saplings. These results provide some support for claims of ACT being able to increase soil microbial biomass and K, but provide minimal support for ACT being able to increase tree growth across multiple species in a variety of soil types. An application rate of 400 kL·ACT/ha may be attainable for trees in containers with limited soil volumes, but this application rate is likely cost-prohibitive, and not practical, in the landscape. At this application rate, $\approx$1000 L of ACT would be required to treat a typical, and relatively small, critical root zone of 25 m$^2$.

Soil nutrient management is important for tree establishment, growth, and longevity. Nutrients are most often supplied to trees in the greenhouses, nurseries, and landscapes by inorganic fertilizers. Nutrient management with inorganic fertilizers poses some environmental risks such as eutrophication of fresh water from phosphorus (P) loading (Soldat et al., 2009), acidification of soils and surface water from phosphorus (P) loading (Soldat et al., 2009), and greenhouse gas production during fertilizer synthesis and after applications through denitrification (Vitousek et al., 1997).

Given the potential risk associated with inorganic fertilizers, organic fertilization is becoming more common for supplying nutrients to trees. Organic fertilizers contain organic matter and encompass a diverse group of materials (e.g., animal or green manure, peat, bone meal, biosolids, compost) (Finck, 1982). The majority of the nutrients in these fertilizers is organically bound and slowly mineralized, so the potential for exceeding plant nutrient demands and associated environmental contamination is reduced relative to synthetic fertilization (Stratton et al., 1995). Because organic fertilizers have lower quantities of immediately available N compared with synthetic fertilizers, they may be less likely to speed up C losses from soil through N stimulation of microbial respiration (Follett et al., 1981; Triberti et al., 2008). The use of organic materials as fertilizer promotes useful recycling and removes potentially noxious waste products (Finck, 1982).

Aerated compost teas are one such organic fertilizer becoming more widely used with the hopes of improving soil quality and managing tree nutrition. Aerated compost tea is made by mixing compost with aerated water (National Organic Standards Board, 2004). Aerating during the brewing process distinguishes ACT from other compost extracts and is important considering the goal of increasing aerobic microorganisms. According to the National Organic Program (NOP), the predominant ACT production method in the United States involves one part compost in 10 to 50 parts water, constant aeration for 12 to 24 h, and immediate application (National Organic Standards Board, 2004). NOP standards specify that compost used to make ACT must be made from allowable feedstock materials and the entire pile must undergo an increase in temperature to at least 131 °F for at least 3 d (National Organic Standards Board, 2002). ACT additives such as molasses, yeast extract, and algal powders are used to encourage growth of beneficial microbes but can also have non-target negative effects by supporting the growth of bacterial human pathogens from undetectable levels in properly made compost to detectable in ACT. The National Organic Standards Board (2004) specifies that ACT made with additives can be applied to ornamental plants, not intended for human consumption, and is exempt from U.S. Environmental Protection Agency standards for a bacterial indicator of fecal contamination.

A growing body of research has been examining the effects of compost teas or extracts on plant growth and disease suppression (e.g., Al-Mughrabi, 2007; Duffy et al., 2004; Ezz El-Din and Hendawy, 2010; Hargreaves et al., 2008, 2009a, 2009b; Hendawy, 2008; Larkin, 2008; Pant et al., 2009, 2011; Puglisi et al., 2008; Scheuerell and Mahaffee, 2002, 2004, 2006; Segarra et al., 2009; Viator et al., 2008; Welke, 2005; Yohalem et al., 1996). These studies have examined ACTs, non-ACTs, teas applied as foliar sprays or soil drenches, and teas with and without additives. For the most part, mixed results have been reported for the effectiveness of compost teas to decrease disease and increase yield for a variety of agronomic and horticultural plants.

Few of these studies have focused on the specific impacts of ACT on soil quality (e.g., Hendawy, 2008; Larkin, 2008; Pant et al., 2009; Puglisi et al., 2008; Scharenbroch et al., 2011) and none have examined the impacts of ACT on examined tree growth. These studies have rarely compared ACT with water, which is known to be a major limiting factor for tree growth (e.g., Scharenbroch et al., 2011). Furthermore, no standards exist for application rates of ACT to trees. Current ACT application rates for agricultural and horticultural plants range from 4 to 400 kL·ACT/ha (personal communication with E. Ingham formerly of Soil Foodweb, Inc., July 2008), albeit these rates are not based on scientific evidence.

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This experiment was conducted to determine the impacts on tree and soil properties of varying rates of ACT. Treatment effects were examined for two tree species (Acer saccharum and Quercus macrocarpa) and three soil types (sand, uncompacted loam, and compacted loam) over 20 months. Varying rates of ACT were examined against water as a control toward identifying an appropriate ACT application rate for trees in containerized settings.

Materials and Methods

The experiment was a full factorial with two species, three soil types, five treatments, and six replicates for a total of 180 experimental units. The two tree species were Acer saccharum and Quercus macrocarpa (planted as 1- to 2-cm caliper bare root saplings). Before planting, the main roots were pruned to a standardized 10 cm length, fine roots removed, and stems were pruned to a 30 cm length.

The three soil types were: a pure sand, an uncompacted loam (1.20 Mg m⁻³), and a compacted loam soil (1.65 Mg m⁻³). The loam soil was collected from a 2-m wide × 3-m deep pit on the grounds of The Morton Arboretum, Lisle, IL. The soil was from the A horizon (0 to 10 cm) of a fine, illitic, mesic Oxyaqual Hapludalf, Ozaukee series soil profile. The sand soil was playground sand consisting of 80% organic nutrients, 20% naturally derived minerals from feather meal, bone meal, cottonseed meal, sulfate of potash–magnesia, alfalfa meal, kelp, soymeal, and mycorrhizae was added at the start of brew (Keep It Simple, Inc.). Humin acid (25 g) and soluble seaweed powder (25 g) were also added at the start of the brew (Keep It Simple, Inc.). During the 24-h brew cycle, dissolved oxygen, temperature, pH, and electrical conductivity (EC) were measured every hour. Dissolved oxygen remained above 6 mg kg⁻¹ with a mean value of 7.3 mg kg⁻¹ throughout the brew cycle. Mean temperature, pH, and EC were 21 °C, 4.9, and 2169 µs cm⁻¹, respectively. On average (10 brews), the ACT contained only a fraction of what was in the compost itself: 1972 µg bacteria/g, 4.9 µg fungi/g (mean hyphae diameter of 2.6 µm), 1920 flagellates/g, 1392 amoebae/g, 7.7 ciliates/g, and 0.1 nematodes/g. Biochemical characteristics of the water and ACT are given (Table 1).

Microcosms were flushed on 13 Apr. 2010, 27 May 2010, 29 June 2010, and 23 Aug. 2010 with 300 mL of deionized and the first 100 mL of leachates were collected, filtered, and analyzed for nitrate (NO₃⁻) using ion chromatography (Metrohm 732/733 Detector and Separation Center, Riverview, FL). Surface CO₂ efflux was measured on 5 June 2009, 15 July 2009, 31 July 2009, 4 Sept. 2009, 13 Oct. 2009, 19 May 2010, 20 June 2010, and 21 July 2010 using static NaOH traps. CO₂ concentrations in the NaOH traps were determined by acid-base titration with HCl to a phenolphthalein end point (Parkin et al., 1996).

Leaf color was assessed with a chlorophyllometer (Konica Minolta SPAD 502 Plus Chlorophyll Spectrum Technologies, Inc., Plainfield, IL) on 5 Aug. 2009, 2 June 2010, 29 June 2010, and 18 Aug. 2010. Five leaves per tree were measured and a mean of the five measurements was calculated. Stem calipers were measured at four cardinal directions at the start and end of the experiment at painted locations on the tree stems to compute diametral growth rates of each tree. In November of 2010, trees were carefully separated from the soils. Trees were washed with deionized water to remove all soil and all leaves were removed. Trees were cut at the root and shoot interface. Shoots and roots were dried at 60 °C for 5 d and then weighed to express shoot, root, total biomass, and the root to shoot ratio (R/S ratio).

At the conclusion of the experiment, soils were sampled from each microcosm. Soil penetration resistance was measured on the soil surface four directions at the midpoint of stem and edge of the microcosm using a pocket penetrometer (Model 29-3729; ELE International, Loveland, CO). Soil was then carefully removed from each microcosm and separated from tree roots. Soil red size was measured on five random intact soil pedds from each microcosm (mm). Soils were then passed through a 6-mm screen and homogenized for further characterization.

Gravimetric soil moisture content was determined by the mass loss after drying soil subsamples at 105 °C for 48 h (Black, 1965). Soil subsamples were extracted with 1 M NH₄OAc (pH 7.0) and mg kg⁻¹ of Ca²⁺, Mg²⁺, K⁺, and Na⁺ were determined with atomic adsorption spectroscopy (Model A5000; Perkin Elmer Inc., Waltham, MA) (Schollenberger and Simon, 1945). Soil P was determined with the Bray P-1 or Olsen extraction methods and analyzed colorimetrically at 882 nm on a spectrophotometer (Model ultraviolet mini 1240; Shidmadzu Inc., Kyoto, Japan) (Olsen and Sommers, 1982). Soil pH and EC in µs cm⁻¹ were measured in 1:1 (soil:deionized water) pastes (Model Orion 5-Star; Thermo Fisher Scientific Inc., Waltham, MA). Total organic matter was determined by loss-on-ignition at

| Response | Loam soil | Sand soil | Water | ACT |
|----------|-----------|-----------|-------|-----|
| pH       | 7.09 (0.1) | 8.89 (0.2) | 7.52 (0.4) | 4.88 (0.1) |
| EC (ds·m⁻¹) | 45 (5.0) | 42 (5.0) | 4.80 (0.5) | 738 (44) |
| Ca (mg·kg⁻¹) | 936 (32) | 508 (10) | 1153 (13) | 1893 (90) |
| Mg (mg·kg⁻¹) | 399 (8.0) | 297 (5.5) | 225 (9.0) | 534 (30) |
| K (mg·kg⁻¹) | 69.4 (4.0) | 70.7 (2.3) | 126 (22) | 164 (52) |
| Na (mg·kg⁻¹) | 37.6 (6.0) | 42.0 (4.2) | 48.1 (2.0) | 42.2 (5.0) |
| P (mg·kg⁻¹) | 0.947 (1.0) | 0.002 (0.0) | 0.601 (0.0) | 4.83 (2.1) |
| NO₃⁻ (mg·kg⁻¹) | 10.0 (0.7) | 2.12 (0.6) | 0.501 (0.0) | 8.32 (0.2) |
| NH₄⁺ (mg·kg⁻¹) | 1.19 (0.5) | 0.063 (0.8) | 1.21 (0.1) | 7.20 (0.2) |
| Dissolved organic N (mg·kg⁻¹) | 16.4 (0.2) | 6.31 (0.2) | 1.22 (0.0) | 5.21 (0.1) |
| Total organic matter (%) | 6.42 (6.4) | 0.123 (0.7) | N/A | N/A |
| Microbial biomass N (mg·kg⁻¹) | 13.6 (3.0) | 0.943 (1.5) | 0.002 (0.0) | 132 (4.0) |
| N minimum (mg NH₄/NO₃ kg⁻¹·d⁻¹) | 0.284 (0.1) | 0.002 (0.0) | 5.280 (0.3) | 21.7 (2.0) |
| Microbial respiration (mg CO₂·kg⁻¹·d⁻¹) | 57.8 (1.0) | 2.58 (0.5) | 0.103 (0.0) | 5.31 (1.1) |

where a ± is the standard deviation and n = 3. *SEM in parentheses with means from six replicate samples. Data not available (N/A) for soil organic matter for water and ACT.

EC = electrical conductivity; Ca = calcium; Mg = magnesium; K = potassium; Na = sodium; P = phosphorus.
Table 2. Soil properties from five aerated compost tea (ACT) treatments, two tree species (Acer saccharum and Quercus macrocarpa), and three soil types (sand, uncompacted loam, and compacted loam).

| Soil response | 0 kL ACT/ha | 2 kL ACT/ha | 4 kL ACT/ha | 40 kL ACT/ha | 400 kL ACT/ha | T | So | Sp | TxSo | TxSp | SoxSp | TSo | TSp | TSoxSp |
|---------------|-------------|-------------|-------------|-------------|-------------|---|----|----|------|------|-------|-----|-----|---------|
| Penetration resistance (kg·cm⁻²) | 1.52 (0.2) | 1.73 (0.2) | 1.33 (0.2) | 1.77 (0.2) | 1.89 (0.2) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Ped size (mm) | 32.1 (19) | 30.2 (1.1) | 29.1 (1.1) | 30.1 (1.6) | 32.1 (1.7) | NS | *** | ** | ** | NS | NS | NS | NS | NS |
| Soil moisture (%) | 16.0 (1.6) | 16.1 (1.7) | 16.7 (1.7) | 17.6 (1.7) | 17.5 (1.7) | NS | *** | ** | NS | NS | NS | NS | NS | NS |
| pH | 7.69 (0.1) | 7.81 (0.2) | 7.88 (0.2) | 7.90 (0.2) | 7.90 (0.2) | NS | *** | NS | NS | NS | NS | NS | NS | NS |
| EC (dS·m⁻¹) | 39.3 (3.1) | 37.3 (2.5) | 36.6 (2.1) | 39.8 (2.7) | 37.8 (2.4) | NS | *** | *** | *** | *** | NS | NS | NS | NS |
| Ca (mg·kg⁻¹) | 277 (21.1) | 274 (21.7) | 278 (34.6) | 277 (33.4) | 278 (36.2) | NS | *** | *** | *** | *** | NS | NS | NS | NS |
| Mg (mg·kg⁻¹) | 365 (9.4) | 404 (14.7) | 401 (13.0) | 410 (17.9) | 405 (19.3) | NS | *** | *** | *** | *** | *** | *** | *** | *** |
| K (mg·kg⁻¹) | 69.9 (2.3) b | 74.8 (2.8) b | 77.4 (3.7) b | 84.1 (3.8) ab | 94.4 (3.8) a | NS | *** | NS | NS | NS | NS | NS | NS | NS |
| Na (mg·kg⁻¹) | 26.5 (3.0) | 27.3 (3.1) | 24.8 (2.8) | 28.1 (3.1) | 28.1 (3.1) | NS | *** | *** | *** | *** | NS | NS | NS | NS |
| P (mg·kg⁻¹) | 0.641 (0.1) | 0.524 (0.1) | 0.428 (0.0) | 0.467 (0.1) | 0.725 (0.8) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| NH₄⁺ (mg·kg⁻¹) | 0.816 (0.2) | 0.844 (0.2) | 0.591 (0.1) | 0.571 (0.1) | 0.566 (0.1) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| NO₃⁻ (mg·kg⁻¹) | 7.39 (1.2) | 6.01 (1.1) | 4.60 (0.6) | 7.11 (1.2) | 4.03 (0.7) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Dissolved organic N (mg·kg⁻¹) | 13.0 (1.4) | 11.4 (1.3) | 11.2 (1.3) | 10.6 (1.1) | 9.19 (1.0) | NS | *** | *** | *** | *** | NS | NS | NS | NS |
| Available N (mg NH₄⁺ + NO₃⁻ + DON kg⁻¹) | 21.2 (2.1) | 18.2 (2.1) | 16.1 (1.7) | 18.3 (1.8) | 13.8 (1.4) | NS | *** | *** | NS | NS | NS | NS | NS | NS |
| Particulate organic matter (%) | 2.56 (0.2) | 2.45 (0.2) | 2.58 (0.2) | 2.45 (0.2) | 2.44 (0.2) | NS | *** | NS | NS | NS | NS | NS | NS | NS |
| Total organic matter (%) | 4.29 (0.5) | 4.24 (0.5) | 4.31 (0.5) | 4.29 (0.5) | 4.39 (0.5) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Microbial biomass N (mg·kg⁻¹) | 9.34 (1.7) | 10.6 (1.6) | 11.2 (1.7) | 11.2 (1.7) | 15.3 (2.1) | * | *** | *** | NS | NS | NS | NS | NS | NS |
| N min. (mg NH₄⁺ + NO₃⁻ + DON kg⁻¹) | 1.43 (0.1) | 0.313 (0.1) | 0.253 (0.1) | 0.294 (0.1) | 0.359 (0.1) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Microbial respiration (mg CO₂ kg⁻₁ d⁻¹) | 26.4 (3.7) | 39.1 (3.8) | 30.8 (3.6) | 30.3 (3.3) | 44.9 (6.8) | NS | *** | NS | NS | NS | NS | NS | NS | NS |
| Surface C efflux (μg C m⁻² d⁻¹) | 29.2 (1.1) | 30.6 (1.0) | 30.4 (1.1) | 29.1 (0.9) | 33.1 (1.0) | NS | *** | NS | NS | NS | NS | NS | NS | NS |
| Leachate NO₃⁻ (mg·kg⁻¹) | 2.82 (0.4) | 2.55 (0.3) | 2.26 (0.3) | 2.89 (0.3) | 2.07 (0.3) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

*SEM in parentheses with means from 36 replicate samples. Any two means within a row not followed by the same letter are significantly different at P ≤ 0.05 using analysis of variance standard least squares and Tukey-Kramer’s honest significant difference. Significance of main effects of treatment (T), soil (So), and species (Sp) and interaction of these terms are denoted as NS, *; **, *** for nonsignificant or significant at P ≤ 0.05, 0.01, or 0.001, respectively, after a Bonferroni’s correction for multiple testing.

Ca = calcium; Mg = magnesium; K = potassium; Na = sodium; P = phosphorus; DON = dissolved organic N; C = carbon; EC = electrical conductivity; N = nitrogen.
Of the soil properties measured, soil K, microbial biomass N, and total available N (NH₄⁺ + NO₃⁻ + dissolved organic N) were the most responsive to the ACT treatments (Table 1). Microbial biomass N and K tended to increase with increasing concentrations of ACT in all soil types and was significantly greater in the highest ACT rate compared with water control in all three soil types (top is loam, middle is compact loam, and bottom is sand). Points on bars are means of six replicates. Significant differences were only observed for Quercus macrocarpa in compact loam soil for total (P = 0.0004), shoot (P = 0.0106), root (P = 0.0003), and the R/S ratio (P = 0.0111). Any two means within a biomass class, species, and soil type not followed by the same letter are significantly different at P ≤ 0.05 using analysis of variance standard least squares and Tukey-Kramer’s honest significant difference.

The best multiple regression model for root biomass included MBN, NH₄⁺, POM, total soil organic matter (SOM), MBN, microbial respiration, N mineralization, and NO₃⁻ in leachates. The best multiple regression model for root biomass included MBN, NH₄⁺, NO₃⁻, and P (R² = 0.48) (Fig. 3). This positive linear relationship was relatively strong with both species and three soil types but weakened with Acer saccharum in compact loam. Root biomass was negatively correlated with the concentration of NO₃⁻ in leachates (R² = 0.26) (Fig. 3). Correlations between root biomass and leachate NO₃⁻ were weaker and not significant for Acer saccharum in compact loam and sand and Quercus macrocarpa in compact loam. The best multiple regression model for root biomass included MBN, NH₄⁺, NO₃⁻, and P (R² = 0.48) (Fig. 3). This positive linear model was not significant for either species growing in sand but was significant for both species and the other two soil types.

**Discussion**

No tree or soil parameters were significantly different with ACT treatment rates at 2, 4, or 40 kL/ha⁻¹ compared with water. Furthermore, the majority of the tree and soil parameters did not differ significantly at any of the ACT concentrations, including water. Some significant effects were observed for soil properties when comparing the highest ACT rate (400 kL/ha⁻¹) with the control, specifically, soil K and microbial biomass N increased with the highest ACT rate compared with water. Total available N decreased with the highest ACT rate compared with water. Differences in tree properties were minimal. Shoot, root, total biomass, and the R/S ratio increased with highest ACT concentration for Quercus macrocarpa in the compact loam soil.

Microbial biomass N increased 94% with a rate of 400 kL ACT/ha compared with
water across these soil types and tree species. In a laboratory incubation study, Scharenbroch et al. (2011) found soil microbial activity to increase with a similar ACT application rate compared with water-treated soils; however, greater increases were observed for soils treated with inorganic N–P–K fertilizer. Pant et al. (2011) also found soil microbial activity to increase 50% with applications of vermicompost tea. It is thought that ACT is a direct source of soluble nutrients (e.g., Ingham, 2003; Lowenfels and Lewis 2007). Nutrient concentrations (Ca, Mg, K, and available N) in the ACT were elevated compared with those in the water treatment. However, only soil K increased with ACT compared with water. Background soil levels, nutrient fixation, tree uptake, volatilization, and leaching losses may be responsible for the non-responses observed for other nutrients. These findings suggest that ACT may increase soil K; however, K is rarely a limiting factor for plant growth. Hargreaves et al. (2008) found soil K levels to be lower.

Fig. 2. Soil microbial biomass nitrogen (N), potassium (K), and available N (NH₄⁺ + NO₃⁻ + dissolved organic N) in loam, compact loam, and sand soils from five rates of aerated compost tea (ACT) treatments (figures on left) and also comparing three ACT treatment rates (figures on right). Bars are means of 12 replicates from species Acer saccharum (left) and Quercus macrocarpa. Any two within a soil type not followed by the same letter are significantly different at $P \leq 0.05$ using analysis of variance standard least squares and Tukey-Kramer’s honest significant difference.
with non-aerated compost teas as compared with inorganic fertilizer, but this was likely the result of the compost teas being applied as foliar sprays and fertilization as a soil application. Conversely, Scharenbroch et al. (2011) found soil K to significantly increase with ACT. The amount of K in ACT was quite high (164 mg·kg⁻¹) and exceeded K applied in a typical N–P–K fertilizer application for trees (Scharenbroch et al., 2011). Compost is known to be high in K, and several studies report increases in soil K from compost (Bar-Tal et al., 2004; Giusti et al., 1988).

Proponents assert that ACT will increase nutrient availability through increases in nutrient mineralization (e.g., Ingham, 2003; Lowenfels and Lewis, 2007). This study provides no direct evidence to support claims of increased N mineralization with ACT compared with water. Other studies on the impacts of compost teas on N mineralization are scarce. Hargreaves et al. (2009b) found N mineralization to be significantly greater in soils treated with municipal solid waste compared with soils treated with teas from municipal solid waste; however, they observed no differences in N mineralization in soils treated with ruminant compost and ruminant compost tea. Scharenbroch et al. (2011) found N mineralization to be greater in soils treated

Fig. 3. Single and multiple regression models for root biomass and soil properties (surface C efflux on top, leachate nitrate in middle, and multiple parameter model on bottom) from five aerated compost tea treatments, two tree species (Quercus macrocarpa and Acer saccharum), and three soil types (sand, uncompacted loam, and compacted loam). R² and P values are given for each model with 95% confidence intervals denoted. Each point is a mean of six replicates.
with inorganic N–P–K fertilizer compared with soils treated with water and ACT with no differences between water and ACT-treated soils.

Significant decreases in available N were found with increasing ACT application rates. The decreases in available N with highest ACT application rate may be a result of decreased N mineralization, increased N leaching, increased N volatilization, increased plant N uptake, and/or increased microbial N immobilization. Significant differences in leachate NO$_3$ and N mineralization were not observed. Scharenbroch et al. (2011) found decreases in microbial biomass to increases in fertility, specifically tent with this species’ negligible responses as saccharum in this study is generally consistent, slow-release nutrient source, and soil condition for preserving and improving soil quality is well supported in scientific study [see reviews by Chalker-Scott (2007) and Scharenbroch (2009)]. In this research, the cost of brewing and applying ACT was 5.7 times greater than the cost of applying the compost as a top-dressing. Furthermore, the compost contained much greater numbers of organisms compared with ACT (six times more bacteria, 724 times more fungi, 10 times more flagellates, 11 times more amoebae, 1473 times more ciliates, and 12 more nematodes in compost compared with ACT). If the goal is to improve and manage soil microbial populations, direct application of compost to the soil should be considered. Future research is needed comparing ACT with no other soil fertility amendments with additional tree species in landscape and containerized settings.

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