An Investigation of the Impact of Compost Tea Applications on Turf Quality and Soil Microbial Activity

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Abstract

This study investigated the effect of compost tea applications on turf quality and soil microbial activity. Evaluations of turfgrass quality were based on The National Turfgrass Evaluation Program's guidelines while soil samples were analyzed for chemical attributes and microbial activity. Four sites and treatments for the study included: 1) a soil drench compost tea application with irrigation, 2) a soil drench compost tea application with no irrigation, 3) no compost tea application with irrigation, and 4) no compost tea application nor irrigation. Fifteen soil samples and turf quality observations from each treatment were collected for pretest data. Then, post-test data were collected after each additional seasonal test period over the course of one year for each of the four plots. For the four plots, the site which received compost tea applications and regular irrigation received significantly higher turf quality ratings, and compost tea improved turf quality ratings beyond that of regular irrigation. No differences were found in microbial populations given the compost tea application. While the study results provided evidence of the value of compost tea to overall turf quality aesthetics, more research is recommended regarding compost tea applications and beneficial soil microbial populations in turf.

Species used in this study: Bermudagrass (*Cynodon dactylon*) L. Pers.

Index words: turf grass, compost, compost tea, soil drench, National Turfgrass Evaluation Program, soil foodweb, soil biology.

Significance to the Horticulture Industry

As the fourth largest crop in the U.S. by acreage, the management of turfgrass is of environmental significance. Additionally, the turfgrass industry continues to grow along with interest in organically managing this crop. However, research regarding the use of compost tea as a management strategy for turfgrass is relatively recent and limited. Studies have suggested that compost soil amendments and teas can reduce reliance on pesticides by suppressing disease, and reduce reliance on fertilizers by increasing soil and plant health. Thus, this study investigated the effects of compost tea soil drench applications on turf quality and soil microbial activity. Results presented in this study provide evidence of the value of compost tea to overall turf quality. Specifically, compost tea improved turf quality ratings beyond that of irrigation applications. While this study illustrates turf quality can be positively impacted using compost tea drenches in turfgrass, more research is needed. Specifically, application timing, rate, and long-term effects of compost tea applications in terms of turf quality and soil biochemical attributes need to be further explored to develop best management practices.

Introduction

The turfgrass industry in the United States continues to grow rapidly due to strong demand for residential, public, and commercial property development (Haydu et al. 2006). Valued at $40-60 billion, turfgrass is estimated to cover 10-20 million hectares (25-50 million acres) in the United States making it possibly the fourth largest crop in acreage, and the largest irrigated U.S. crop by three times (Milesi et al. 2005, Morris 2006, Robbins and Birkenholtz 2003). While turf is used for its recreational value and aesthetics, it also provides many environmental and ecosystem function benefits, including a reduction in soil erosion, improved water infiltration and reduced runoff, water purification, toxic remediation, carbon sequestration, and cooling to mitigate urban heat island effects (Beard 1996, Beard and Green 1994, Chang et al. 2021).

Despite the many benefits of turfgrass, environmental issues have arisen due to the management of turfgrass, which includes high water consumption, incorrect use of fertilizers and pesticides (Helfand et al. 2006), and the production of volatile organic compounds (Harvey et al. 2014). In the U.S. as well as in other parts of the world, more than 50% of domestic water usage is allocated to residential landscape irrigation (Haley et al. 2007). In Texas, it is estimated that the combined water usage of golf courses and landscapes is 46.6% of total water use within the municipal and urban sector (Chang et al. 2021). Additionally, the management of turfgrass and urban lawns significantly contributes to nonpoint source water quality issues (Robbins et al. 2001). According to the United States Environmental Protection Agency (1996), 23% of the total 2,4-D applied nationally is used on lawns, as well as 22% of glyphosate, 31% of chlorpyrifos, and 38% of dicamba used.

While agriculture and industry are often targeted as culprits of environmental issues, land cover and runoff from urban and suburban areas, where most turfgrass is grown, is often overlooked in regulations (Capiella and Brown 2001, Robbins and Sharp 2003). More recently, Minnesota became the first state to restrict fertilizer use on turfgrass to reduce phosphorus runoff (Minnesota Department of Agriculture 2007). Additionally, some states such as Connecticut and New York have banned the use of

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turfgrass pesticides on public and private school grounds including athletic fields (Miller and Henderson 2012).

Due to these turfgrass management concerns, and increased awareness of the environmental and health benefits of organic crop production methods, a growing interest and market for the use of organic production methods and soil amendments on turfgrass is emerging. (Quarles 2010). As an alternative to chemical fertilizers and pesticides within an integrated pest management strategy, compost and aqueous solutions made from compost are used by organic farmers, municipalities, and park and recreational facilities (Dearborn 2011). Research has suggested that the use of compost soil amendments, including compost tea, can reduce reliance on pesticides and fertilizers while suppressing disease and pests (Scheuerell and Mahaffee 2002). Furthermore, compost tea applications are used to increase soil and plant health, and increase availability of plant nutrients, and beneficial soil microorganisms (Arancon et. al. 2007, Dearborn 2011, Hargreaves et al. 2008, Ingham 2005).

While compost is bulky to transport, and high-quality compost can be prohibitively expensive and difficult to apply to areas that are in turf production, compost tea may offer a practical alternative for integrated pest management. Additionally, organic matter applied to turf used for recreation is generally not desirable, thus compost application may not be recommended (Dearborn 2011). Compost tea is a liquid made by steeping compost in water to promote leaching of nutrients and beneficial microorganisms from the compost (Ingram and Millner 2007). Supplemental aeration, sugars and nutrients may be added to increase beneficial microbial populations. Compost tea can be applied over larger areas per volume of compost utilized. Although compost tea benefits have been shown, the beneficial effects of compost tea may be short-lived, and frequent and repeat applications may be necessary, particularly when soil has been degraded and soil microbial populations are low in number and/or diversity (Ingham 2005, Scheuerell and Mahaffee 2002).

There are two generally accepted methods of compost tea application: foliar spray and soil drench. While foliar application of compost tea has been shown to suppress foliar diseases (Scheuerell and Mahafee 2004), soil drenches facilitate beneficial soil microbial populations. Studies have shown that compost tea application to the rhizosphere via soil drench has increased plant yield and root growth (Eudoxie et al. 2017, Pant et al. 2011, 2012) and suppressed soil pathogens (Islam et al. 2014). Although aqueous compost extracts have had a long history in agriculture, research regarding the benefits and most effective applications of compost tea, and particularly with respect to turfgrass, is relatively recent (Radovich et al. 2012). Thus, the purpose of this study was to investigate the effect of compost tea soil drench applications on overall turf quality and soil microbial activity.

Materials and Methods

Study sites. This study included two 5.6-m^2 (60-ft^2) bermudagrass (*Cynodon dactylon* L.) sites on the grounds of Texas State University. Study site 1 was utilized by Texas State University to host events and group tours and was characterized by compacted soil from excessive foot traffic and exposed topsoil with patchy turf coverage. Study site 2 was used as parkland, was characterized by full turf coverage, and received less foot traffic.

Study site 1 and site 2 each contained two 2.8-m^2 (30-ft^2) plots – one control and one compost tea plot each. Site 1 (including control and compost tea plots) was artificially irrigated weekly with chlorinated municipal water during the study; site 2 (including control and compost tea plots) was not irrigated. Both sites were in full sun with no nearby tree canopy. Sites were within 0.2 km (0.125 mi) of each other to best standardize soil type and ambient environmental conditions.

Compost tea. Each of the four plots was marked with metal flagged pins at each corner of the section. Compost tea plots in site 1 and 2 received the regular application of 45 L (12 gal) of compost tea. Control plots in sites 1 and 2 did not receive any compost tea application. Both study areas underwent normal maintenance performed by grounds crews, which included regular mowing but no fertilizer applications.

Using a soil drench method, compost tea was applied to plots within two hours of brewing using simple gardening watering cans for application. The watering cans were chosen for use in the study because they distribute an even application of compost tea to effectively soak the soil while being the easiest tool to control by hand.

Application times varied throughout the year to adjust for daylength. During rain events, applications were delayed. Four applications were given every other week for a period of two months for four seasonal test periods. The first test period began in early April and ended in late May. The second test period began in mid-July and ended in mid-August. The third test period began in early October and ended in mid-November. The final test period began in late January and ended in early March.

Brewing compost tea. Compost tea applied to the plots of site 1 and 2 was developed using the extraction procedure adapted from Erath Earth (Dublin, TX). This procedure used an industrial-sized compost tea brewer (Erath Earth, Dublin, TX) and the industry standard compost tea recipe which included 757 L (200 gal) of water, 15 L (4 gal) finished compost, 6.8 kg (15 lb) of Chilean non-synthetic organic sodium nitrate (15-0-2; 1443 kg/ha N; Hoss Tools, Park, GA), and 3.8 L (6 gal) of horticultural molasses (Medina Agriculture Products Co., Hondo, TX).

The compost used in the compost tea brewing was developed at Texas State University and derived from university cafeteria food waste, university mixed grounds waste and shredded bark mulch. The compost used in the brewing is regularly tested to ensure it meets current compost quality industry standards (Sanders et al. 2011, Walsh and Waliczek 2020) including those for pH levels, soluble salt content or electrical conductivity, moisture content, organic matter content, total nitrogen, total carbon, carbon to nitrogen ratio, phosphorus, potassium, calcium, magnesium, particle size, and metals arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and

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zinc. Respirometry and bioassay tests were also conducted to observe maturity and stability measurements of compost used in brewing (United States Composting Council, 2002).

Each ingredient was added and mixed for 20 minutes. The first 20 minutes cycled 757 L (200 gal) of water without any added ingredients in order to aerate the water while evaporating chlorine found in the tap water. Next, finished compost was added to the water and dissolve into solution over a period of 20 minutes. Lastly, the Chilean nitrate and molasses were mixed for 20 minutes to feed the microbiology and aid in their multiplication. This combination of materials has been tested in previous studies and shown to promote the greatest numbers of microbes as the microbes consume the sugars and nitrogen (Hegazy et al. 2015).

Turf quality data. Fifteen turf quality observations were randomly collected from each of the four plots within irrigated and non-irrigated control and compost tea sites. Thirty observational samples were gathered from site 1 and thirty from site 2 each time data was collected. Thus, a total of 240 observational samples were collected each season. Observational samples were taken for four seasonal test periods over the course of one year. Observational sampling corresponded to active growing seasons for the turf species with no sampling occurring during the winter when turf was dormant. All observational sampling and ratings were conducted by one researcher to maintain consistency.

The step point intercept method was used to assess turf quality (Wilson 2010). The samples were chosen at random by tossing a small rock inside of the designated grid. One side of the rock had the longest edge, which was 5 cm (2 in) long, and the section of turf adjacent to this edge after it landed was the section used for collecting data. Each sample consisted of a 5-cm by 5-cm (2-in by 2-in) section of turf for which the quality was assessed based on a scale of 1 to 9 among several variables.

Turf quality ratings were based on the variables of color, turf density, uniformity, percent living ground cover, and the texture of the turf using The National Turfgrass Evaluation Program standards (Morris and Shearman 1998). Among turf specialists, the procedure for measuring turf grass quality is known to be subjective and generally based on aesthetics and functional use (Morris and Shearman 1998).

Color was based on a visual rating with 1 being light green and 9 being dark green (Morris and Shearman 1998). The University of California Cooperative Extension developed a leaf color chart helpful in measuring plant nitrogen levels (Mutters 2003). This chart was used as a reference guide to maintain a consistent color rating. Turf density was based on a visual rating of the number of tillers or living specimen of interest within the 5 cm by 5 cm selected areas. Areas with no species living turf species of interest within the plot were excluded from sampling. The Likert-scale rating was based on a scale of 1 to 9 with 9 being the maximum density and 1 showing minimal plants of any species present. Uniformity was based on a visual rating of the ratio of turf to weeds or other species present within each area selected. A scale of 1 to 9 was used with 9 representing an area with no weeds or other specimen while 1 was an area with the majority weeds or other specimen. Percent living ground cover was based on a visual rating of the surface area that is covered by turf within each 5 cm^2 section. Again, the Likert-scale rated 9 as being entirely flourishing and alive and 1 representing areas of struggling turf with only sparse amounts of living turf (Morris and Shearman 1998). Turf texture was based on a visual rating of leaf width. The scale of 1 to 9 was

Table 1. Comparisons of turf quality indicators in the study of the impact of compost tea applications on turf quality and soil microbial activity.

Variable / Group	Mean	SD	F	df	*P*
Color[zut]			10.922	3	0.001*
Compost tea, no irrigation (site 1)	5.75	7.929			
Control, no irrigation (site 1)	5.35	7.285			
Compost tea, irrigation (site 2)	6.85	7.397			
Control, irrigation (site 2)	5.91	8.649			
Density[yut]			11.912	3	0.001*
Compost tea, no irrigation (site 1)	4.48	1.457			
Control, no irrigation (site 1)	3.42	1.706			
Compost tea, irrigation (site 2)	6.62	1.460			
Control, irrigation (site 2)	5.58	1.381			
Uniformity[xut]			13.269	3	0.000*
Compost tea, no irrigation (site 1)	6.27	2.840			
Control, no irrigation (site 1)	3.83	2.970			
Compost tea, irrigation (site 2)	6.73	2.276			
Control, irrigation (site 2)	6.60	1.993			
Percent Living[wut]			10.472	3	0.001*
Compost tea, no irrigation (site 1)	5.12	2.28			
Control, no irrigation (site 1)	4.13	2.507			
Compost tea, irrigation (site 2)	6.97	1.957			
Control, irrigation (site 2)	6.00	1.756			
Texture[vut]			15.032	3	0.000*
Compost tea, no irrigation (site 1)	5.80	1.884			
Control, no irrigation (site 1)	4.87	1.863			
Compost tea, irrigation (site 2)	7.10	1.410			
Control, irrigation (site 2)	6.25	1.398			
Overall turf quality mean score[ut]			23.785	3	0.000*
Compost tea (no irrigation)	5.48				
Control (no irrigation)	4.32				
Compost tea (irrigation)	6.85				
Control (irrigation)	6.11				

*Signifies statistically significant at $P \leq 0.05$.

[z]Color was based on a visual rating with 1 being light green and 9 being dark green.

[y]Turf density was based on a visual Likert-scale rating of the number of tillers or living specimen of interest within the 5 cm by 5 cm selected areas with 9 being the maximum density and 1 showing minimal plants of any species of interest present.

[x]Uniformity was based on a visual Likert-scale rating of the ratio of turf to weeds or other species present within each area selected with 9 representing an area with no weeds or other specimen while 1 was an area with the majority weeds or other specimen.

[w]Percent living ground cover was based on a visual Likert-scale rating of the surface area that is covered by turf within each 5 cm^2 section with 9 being entirely flourishing and alive and 1 representing areas of struggling turf with only sparse amounts of living turf.

[v]Turf texture was based on a visual Likert-scale rating of leaf width with 1 representing a coarse or wide leaf blade and 9 being rated for turf with a fine and thin leaf blade texture.

[u]A rating of at least 6 on any of the Likert-scale scales is considered acceptable.

[t]The National Turfgrass Evaluation Program standards (Morris and Shearman 1998) were used to evaluate turf plots.

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Table 2. **Soil microbial analysis in the study of the impact of compost tea applications on turf quality and soil microbial activity.**

	Compost tea – Irrigation (site 1)		Control – Irrigation (site 1)		Compost tea – No Irrigation (site 2)		Control – No Irrigation (site 2)		
Variable (units)	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Desired level[z]**
Active fungi (μg/g)	15	10	20	0	0	5	0	0	>75
Total fungi (μg/g)	399	0	184	0	148	199	0	0	100-300
Active bacteria (μg/g)	25	30	70	16	42	11	12	13	>75.00
Total bacteria (μg/g)	1989	1826	1876	1753	1,764	1063	561	1875	100-3000
Actinobacteria (μg/g)	16.5	0	1.66	0	0	6.12	0	0	<20.00
AF:AB	0.6	0	0.285	<0.01	<0.01	0.187	<0.01	<0.01	0.01-10.00
TF:TB	0.2	<0.01	0.098	<0.01	0.08	0.454	<0.01	<0.01	0.75-1.5
Protozoa									
Flagellates (MPN/g)	20,380	0	0	0	0	0	0	0	~
Amoebae (MPN/g)	40,760	61,140	0	4,076	0	0	0	0	~
Ciliates (MPN/g)	0	0	0	0	0	0	0	0	~
Nematodes									
Bacterial (no./g)	0	0	0	0	0	0	0	0	~
Fungal (no./g)	0	0	0	0	0	0	0	0	~
Fungal/root s (no./g)	0	0	0	0	0	0	0	0	~
Predatory (no./g)	0	0	0	0	0	0	0	0	~
Root nematodes (no./g)	0	0	0	0	0	0	0	0	~
pH	7.53	7.53	7.93	7.63	8.11	8.05	8.01	8	~
Organic matter (%)	13.04	9.942	11.12	11.03	5.58	6.69	5.38	10.38	~
Electrical conductivity (μS/cm)	498	1000	313	650	246	356	320	270	<1000.00

[z]Desired levels included by Harrington's Organic Lawn Care and determined from Soil Foodweb methods developed by Dr. Elaine Ingham.

used with 1 representing a coarse or wide leaf blade and 9 being rated for turf with a fine and thin leaf blade texture. A rating of at least 6 on any of the scales is considered acceptable (Morris and Shearman 1998). These scores were again taken at a time when the turf was actively growing.

Soil sampling and data collection and processing. Soil at each research site is classified as Blackland Prairie, a fertile dark clay soil. Soil samples were randomly taken before and after each seasonal test period for each plot and included four soil samples from each 2.8-m^2 (30-ft^2) section for a total of 16 samples collected during each of the four seasons and sampling. Soil samples were collected from four inches deep and two inches wide. Samples were stored in sealed plastic bags until they were shipped for lab analysis. Soil biochemical and microbiology evaluation was performed by Harrington's Organic Land Care soil testing (Bloomfield, CT). Variables quantified included total bacteria, total fungi, fungi to bacteria ratio, presence/absence of protozoa (ciliates, amoebae, flagellates), presence/absence of nematodes, percent organic matter, pH, and electrical conductivity.

Data analysis. Data was analyzed for descriptive statistics and frequencies using statistical software (IBM SPSS Statistics version 22.0; IBM Corp., Armonk, NY). Differences amongst responses from groups were found using analysis of variance (ANOVA) tests.

Results and Discussion

Turf quality. Site 1 compost tea plot, which received compost tea applications and regular irrigation, had statistically significantly greater scores and better turf quality ratings ($P<0.001$) across all variables when compared to site 1 control and site 2 compost tea and control plots. Specifically, Table 1 shows the highest ratings for color, density, uniformity, percent living and texture for site 1 irrigated compost tea plot, despite this site typically receiving more foot traffic and its soil being more compacted, as compared to site 2, which was non-irrigated. Turf color ratings included high standard deviations which were likely due to the seasonality of ratings. Additionally, as shown by Table 1, compost tea applications improved turf quality ratings statistically beyond that of regular irrigation. Site 2, which was not irrigated, shows higher ratings in its compost tea plot for color, density, uniformity, percent living, and texture. The overall turf quality mean was also statistically highest for site 1 compost tea with irrigation (Table 1).

Soil microbiology. Measurements of microbiology from the commercial lab where soil samples were sent were used in ANOVA comparisons and reported no significant differences in comparisons based on compost tea applications ($P>0.05$). Some functional groups (e.g., fungi, protozoa, nematodes) decreased after compost tea was added, while others increased. Fungi biomass decreased in both irrigated sites (control and compost) as shown in Table 2. A possible reason may be due to chlorine in the municipal water supply which can have a detrimental effect on beneficial soil microorganisms (Dearborn 2011, Ingham 2005). Organic matter content appeared to increase in the two non-irrigated plots but appeared to decrease in the compost tea irrigated plot over the course of the study. Several case studies have recommended the need for repeated tea applications before getting consistent population increases and stabilization across the functional groups (Ingham 2005, Scheuerell and Mahaffee 2002).

The results of this study are consistent with the previous work indicating the beneficial effects of compost tea. However, there is a general lack of conclusive scientific evidence on the effect of compost type, aeration, and

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brewing time on the properties and efficacy of compost teas used as biocontrol agents and liquid fertilizers, especially on turf. Past studies have focused primarily on the disease suppressive properties of compost tea, with less focus on phytotoxicity and plant nutrients in compost teas (Haggag and Saber 2007, Martin 2014, Scheuerell and Mahaffee 2006). Also, past studies indicated that the beneficial effects of compost tea may be short lived, and frequent and repeat applications may be necessary, especially when soil has been degraded and soil biology is lacking (Ingham 2005, Scheuerell and Mahaffee 2002). Overall, this study illustrates the complexity of controlling features of compost and compost tea production and application, and the need for more research to understand how to effectively utilize compost teas in turfgrass.

Overall, results presented in this study provide evidence of the value of compost tea to overall turf quality. Specifically, plots with compost tea applications showed improved turf quality ratings beyond that of adding irrigation. Compost tea applications correlated with increased ratings of the compost tea and irrigated site to that of "acceptable" based on the turf quality scale by Morris and Shearman (1998). While this study illustrates the potential for turf quality to be positively impacted using compost tea drenches in turfgrass, more research is needed. Specifically, application timing, rate, and long-term effects of compost tea applications, in terms of turf quality and soil biochemical attributes need to be further explored. Additionally, this study was limited due to the potential influence of the nitrate additives to the compost tea. Future studies should include a treatment that has a similar proportions of chemical fertilizer to the nitrate analysis used in the compost tea recipe in order to separate fertilizer impacts from other components of compost tea treatments.

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