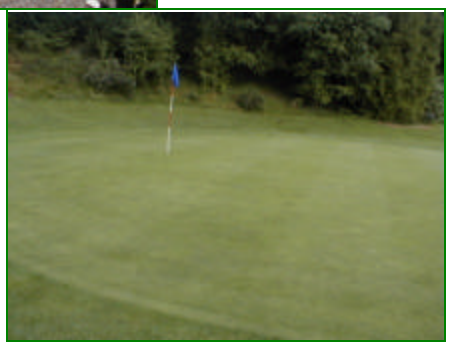
Compost Tea Trials Final Report



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By
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Acknowledgements

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1. Introduction

Purpose of Study

During the summer of 2000, the City of Seattle's Office of Environmental Management launched a series of compost tea trials in three of Seattle's city parks. The City has pledged to reduce the use of chemicals in city parks and other city properties in an effort to reduce the impact of city landscape management on the environment. The trials were conducted at the Woodland Park Rose Garden, Jackson Golf Course, and Prichard Beach Park. The aim of this study was to test compost tea in three managed landscapes in an effort to identify alternatives to traditional pest and pathogenic control. The study was designed as a trial survey and not a scientific study, thus the methodology and monitoring efforts were developed to provide observation-based results.

Cascadia was hired to develop the protocols, methodology and design of the studies with input from the City, and the City was to make and apply the tea at each of the three sites. Owing to the large labor requirements of the compost tea applications, Cascadia undertook the application of the tea at both Jackson Park Golf Course and Woodland Park Rose Garden, while the City applied tea at the Pritchard Beach site.

What is Compost Tea?

Compost tea is a solution created by extracting microorganisms and nutrients from compost. Specific types of compost are used to create an optimal balance of fungal organisms, bacteria and beneficial microbes suited to the plant community under consideration. These organisms occur naturally in the soil and are associated with the normal functioning of plant tissues and the maintenance of healthy soil. The organisms in a healthy soil food web function to:

- Protect roots and other plant tissues from pathogens and disease
- Provide nutrients to plants in an easily assimilated form
- Increase available water to plant roots
- Improve overall health of plants

Suspension of beneficial microbes from compost or animal waste is a long-practiced activity in agriculture and farming. The practice of making compost tea dates back to the Roman and early Egyptian periods. The application of compost tea in urban settings, however, is just emerging. Prolonged use of chemicals and inorganic fertilizers can lead to the loss of beneficial organisms in urban landscapes. Compost tea has been demonstrated to be an effective source of beneficial organisms can help restore the natural functions of healthy soil. Trial studies of compost tea on golf courses and turf grass have been underway for several years across the country including Red Hawk Golf Club in Sparks NV, the Los Angeles Country Club, Red Mountain Ranch Country Club in Mesa AZ, North Shore Country Club in Glenview Il, and Bandon Dunes, OR. Other cities including San Francisco and Austin have developed integrated pest management studies that include compost tea in their management protocols. Soil Foodweb Incorporated of Corvallis Oregon has

also been active in developing and testing protocols for making and applying compost tea to turf and other vegetation types.

In addition to the City of Seattle's compost tea trials, several other public and private landowners or managers in the Puget Sound region are using compost tea in managed gardens and landscapes including and the University of Washington and the cities of Issaquah and Bellevue. In Harmony Landscaping Service, one of the largest organic landscaping companies in the region, regularly uses compost tea in their landscape maintenance services.

Report Format

This report contains methodology and results from the three compost tea trial studies; the Rose Garden (Section 2), Jackson Golf Course (Section 3) and Prichard Beach (Section 4). The report is organized into sections by site, with each section containing an introduction, methodology and result section. Final conclusions from the entire study follow in Section 5.

2. Woodland Park Rose Garden

Introduction

The rose garden at Woodland Park encompasses 2.5 acres on the grounds of the Woodland Park Zoo. It was first opened in 1924 and the collection currently consists of 260 varieties of roses totaling over 5,000 plants.

While the Northwest offers optimal growing conditions for roses, it also provides optimal growing conditions for diseases of roses, in particular fungal diseases in including black spot (Diplocarpon rosae) and powdery mildew (Erysiphaceae). In an attempt to reduce the use of chemicals to control these diseases, the rose garden staff is testing compost tea on roses in several test beds to evaluate the effectiveness of the tea in maintaining plant health. The objective of the trial study was to determine if compost tea applied to the soil and foliage could:

- Reduce the incidence of foliar disease
- Reduce the spread of disease
- Improve the vigor and health of study plants

This first season of compost tea trials offered some valuable feedback on the effectiveness of compost tea on roses. While early season results were favorable, by the middle of August, most of the less resistant varieties began to show rapid decline from black spot. This may have been due in part to the late start of the initial application (which occurred when buds and foliage had already emerged on many varieties). Infection by spores may have already taken place at by this time. Also, the possible presence of residual chemicals still in the soil may have had a negative effect on the compost tea organisms. However, the soil tests did not investigate the presence of chemical residuals; additional soil tests are needed to learn more of the baseline condition of the soils. In addition, further studies are needed to determine the best procedure and protocol for the test beds.

Another rose garden compost tea study took place in Seattle concurrently with the Woodland Park rose garden trials, at the University of Washington. During the summer of 2000 (July 6 – September 15) the University grounds staff treated half of the rose garden around the central fountain (about 400 plants) with weekly foliar applications of compost tea. The remaining half of the garden was treated conventionally. A 10:1 concentration of tea was applied using compost tea made with from fruit compost provided purchased through Growing Solutions. By mid-August, the chemically treated roses had little or no disease whereas the compost tea roses were experiencing some blackspot. However, by the end September, both the compost tea and conventionally treated beds looked comparable relative to black spot and powdery mildew, and the bloom quality and quantity were comparable. The University plans to extend the use of compost tea on all rose plants in the upcoming summer, with applications beginning March 1 before bud-break and leaf emergence.

Methodology

Site selection Three test sites were selected for the compost tea trials at the rose garden. All three sites are located in the southern end of the rose garden (See Figure 1). One site consisted of eight beds clustered on the south side of the walkway (Site A). Sites B and C are located adjacent to site A on the north side of the walkway. The selection criteria for these sites involved: a) choosing beds located some distance from conventionally-treated beds to reduce drift of chemicals into test beds, b) selecting beds with an assortment of varieties to observe the range of responses between varieties to compost tea, and c) coordinating with other alternative management practices underway in the rose garden. Site A received only compost tea during the study period, while site B received Ultimate Rose Food® fertilizer in the spring and site C received traditional fertilizer (Sustain® by Evergro) in the spring.

Site B and C have similar sunlight exposure and thus growing conditions may be similar for rose varieties in these beds. Site A, however, consists of 9 beds that lie mainly in the shade of large overstory trees to the south. This shading influence may have resulted in different physiological responses than those varieties in the more exposed and warmer beds. Although no temperature, radiation or soil moisture measurements were collected during this trial study, the results from this site may differ from sites B and C in part because of the different physical factors of the site.

Brewing compost tea

Compost tea was brewed every two weeks beginning May 11. A 12-gallon Growing Solutions tea brewer was used to brew tea for the rose garden study. The tea brewer was located near a shed adjacent to the rose garden. De-chlorinated tap water was used for each brewing. The water was de-chlorinated by filling the brewer tank with 12 gallons of water directly from the tab and leaving the lid ajar for a minimum of 24 hours to allow the chlorine to de-gas. The tea was brewed with the following proportion of ingredients:

12 gallons de-chlorinated tap water
7 pounds fresh compost (for information on source, see below)
16 oz. unpreserved molasses
2 oz. soluble Atlantic kelp

Compost, molasses and kelp were added to 12 gallons of de-chlorinated tap water and the brewer ran for 18-20 hours. The resulting concentrate was diluted 1:10 with de-chlorinated tap water before applying to soil and foliage.

Compost source

There were two sources of compost for the rose garden study. For the initial soil drench (first application of the study, May 12) a fungal-dominated compost from Columbia River Gorge Organic Fruit Company was used to brew the compost tea. For the remaining applications throughout the study, a custom blend of bacterial-dominated compost from Seattle's Interbay P-Patch was used to make the tea. The P-Patch composts green garden waste with some manure. Every two weeks, the P-Patch mixed and screened approximately 7 pounds of compost for the rose garden study. The compost was mixed and screened one to two days prior to brewing to ensuring that each batch was fresh. One sample of Interbay P-Patch compost (the initial fungal-dominated batch) was tested for microbial activity and the following Table 1 summarizes the outcome of the test for bacteria, fungus and available nitrogen .

Table 1. Results of selected microbial activity test on Fungal-Dominated Interbay P-Patch Compost , April 24, 2000

Organism	Quality of Compost	Measured value (Desired range in parenthesis)
Active bacteria biomass	Great	28.3 (15-30)
Total bacteria biomass	Excellent	2781 (150-300+)
Active fungal biomass	Great	18 (2-10)
Total fungal biomass	Great	1,100 (150-200+)
Available N to plants	Excellent	400+ (based on ratio of protozoan and nematode consumption of bacteria and fungi)

Compost tea application

The first application of compost tea (May 12, see Table 2 below) was applied to the soil as a "soil drench". The purpose of the "soil drench" is to saturate the soil with the compost tea allowing the beneficial organisms to come indirect contact with the soil. This initial application was an effort to return some microbial activity to the soil. Subsequent applications of compost tea were applied every two weeks to the foliage and stems of the rose plants. An additional soil drench was applied approximately half way through the study period. Additional applications of concentrated (100%) compost tea were applied using a hand-held flower mister on individual plants and leaves where black spot was severe. This was done twice, on August 3 and August 22.

Table 2. Application dates and details for tea applications during summer, 2000

Application Date	Concentration tea:water	Soil drench	Foliar spray (dilute)	Foliar spray (concentrated)	Type of compost used
5/12/00	1:10	✓	✓		Fungal- dominated
5/26/00	1:10		✓		Bacteria- dominated
6/9/00	1:10		✓		Bacteria- dominated
6/23/00	1:10		✓		Bacteria- dominated
7/6/00	1:10		✓		Bacteria- dominated
7/21/00	1:10		✓		Bacteria- dominated
8/3/00	3:10		✓	✓	Bacteria- dominated
8/22/00	3:10	✓	✓	✓	Bacteria- dominated
9/1/00	3:10		✓		Bacteria- dominated
9/18/00	1:10		✓		Bacteria- dominated
9/30/00	1:5		✓		Bacteria- dominated
10/14/00	1:5		✓		Bacteria- dominated
10/28/00	1:5		✓		Bacteria- dominated

Soil testing

Soil microbial activity tests were conducted twice during the study period. Four samples of soil were taken from scattered locations within each test site at a depth of the root layer. The soil samples were mixed together in a ziplock bag and one ¼ cup sample from this mixture was sent to Soil FoodWeb Inc via Federal Express for microbial analysis.

Initial soil samples (pre-compost tea treatment) were taken from site A on March 30, and from test sites B and C on May 3. The second soil samples were collected August 22 from all three test sites as well as a sample from one of the conventionally treated beds.

Leaf sampling

Leaf samples were collected from randomly selected plants in beds from Test Site A prior to the initial compost tea application (soil drench) on March 31. Three or four leaves per bed were collected and sent via Federal Express to Soil Foodweb Inc.

Leaves were sampled from test sites A, B and C, as well as from one conventional bed on July 25. Because the test sites B and C were added to the study following the initial soil drench, it was not possible to obtain "pre-tea" leaves from these test sites. Therefore, leaf assays were only conducted in July for sites B and C. Leaf samples from a conventionally managed bed were collected in July in order to compare the microbial coverage between tea-treated and conventionally-treated sites.

Photo documentation

Study sites were photographed several times throughout the study period to document condition of foliage and presence of pathogens and disease. Due to the large number of varieties of rose in the study sites, it was not possible to photograph each variety during the course of the study. Those varieties the exhibited dramatic changes in leaf appearance due to black spot or powdery milder, or that retained noteworthy vigor during the study were documented.

Site monitoring

Sites were monitored every two weeks through visual evaluation. Julie Kintzi, the senior rose gardener at the Woodland Ppark Rose Garden, conducted a visual evaluation of the roses plants in the study sites and documented changes in foliage (noting presence of black spot and other disease, and overall condition of plants) on a monitoring sheet.

Results

Foliage Disease

Black spot is one of the most common rose diseases and was monitored during the course of the study. Blackspot is easy to identify causing clearly visible black patches on mature foliage and can cause premature foliage senescence. Compost tea that is bacteria-dominated sprayed on the foliage can help reduce the site availability for diseases on the leaf surface. It is possible that compost tea can protect the leaf from infection by black spot and powdery mildew, although experimental studies to prove this have not been published. Powdery mildew and rust are also common fungal organisms, but not as widespread. For the purposes of this study, blackspot was monitored on all varieties with rust and mildew noted when visible.

Rose plants in the compost tea-treated sites appeared to be in comparable foliar health and vigor to the conventionally treated plants during the early period of the study (May through the end of July). By late July some varieties in the test beds had begun to display evidence of blackspot, but the disease was not widespread and covered between 2-10% of leaf and less than 10% of infected plants. By early August, many varieties that were showing slight signs of black spot infection began to show more severe signs of infection (20% of leaf; 30% of plant). By early September, many varieties were severely distressed (with disease covering as much as 40% of leaf and 70% of plant). However, the disease may have become more aggressive during the month of August when plants may have been experiencing some drought stress brought on by high temperatures and no natural precipitation. (Plants were watered every two weeks during the summer weeks except when temperatures exceeded 85 degrees F, in which case they were watered weekly.) In the conventional beds, black spot did not exceed 15 % of leaf or plant during the duration of the study.

Table 3 lists the two varieties of rose that exhibited blackspot at the onset of the study period. Across all study sites there was very little blackspot (about 1% of study sites) with the exception of these two varieties.

Table 3 Percent cover of blackspot at initial baseline observation on May 10.

Rose Variety	Baseline Percent Cover with Blackspot
Graham Thomas	10-20% leaf, 10% of plant
Mount Hood	30-40% leaf, 10% of plant

Table 4 provides details on the chronology of foliar injury to varieties that exhibited some degree of black spot disease in the compost tea-treated beds. The observations from September 18th also include approximation of the total remaining foliage on the varieties listed. Several varieties including Intrigue, Little Darling, Handel and Mount Hood lost over 50% of their foliage by the middle of September.

Table 4. Percent leaf cover and percent plant cover with blackspot during trial study period.

	Percent Leaf Cover with Blackspot (Percent Plant Cover With Blackspot in Parenthesis)			
Rose Variety	June 9	July19	August 25	September 18
Big Purple	<1	1 (5)	15 (45)	40 (40) [75% foliage remaining on plant]
Blue Nile	<1	<1	10 (20)	40 (10) [40% foliage remaining on plant]
Capistrano	< 1	1 (1)	30 (20)	30 (50) [95% foliage remaining on plant]
Casablanca	2 (1)	<1	20 (20)	50 (30) [75% foliage remaining on plant]
Chicago Place	<1	20 (40)	30 (35)	50 (60) [70% foliage remaining on plant]
Dicky	20 (20)	40 (40)	10 (10)	20 (20) 80% [foliage remaining on plant]
Electron	<1	<1	20 (20)	
Fairbrianca	<1	2 (20)	10 (20)	30 (30) [85 % foliage remaining on plant]
Gertrude Jekyl	2 (10)	10 (30)	10 (10)	30 (10) [65% foliage remaining on plant]
Graham Thomas	5 (15)	20 (60)	5 (15)	40 (60) [90% foliage remaining on plant]
Handel	15 (11)	2 (20)	10 (15)	40 (5) [40% foliage remaining on plant]
Heritage	<1	10 (10)		50 (60) [85 % foliage remaining on plant]
Intrigue	2 (5)	1 (1)	20 (70)	20 (10) [Only 20% foliage remaining on plant]
Little Darling	30 (20)	30 (65)	5 (70)	30 (40) [40% foliage remaining on plant]
Marijke Koopman	20 (30)	20 (20)	15 (20)	30 (10) [60% foliage remaining on plant]
Marmalade Sky	<1	<1	10 (15)	25 (1) [85% foliage remaining on plant – these have perked up considerably]
Milstone	<1	10 (15)	30 (40)	30 (25) [60% foliage remaining on plant]
Mt. Hood	20 (30)	30 (30)	15 (20)	No black spot visible but only 35% of foliage on plants
New Zealand	<1	5 (10)	40 (60)	30 (30) [60% foliage remaining on plant]
Oriental Charm	<1	<1	20 (15)	40 (40) [80% foliage remaining on plant]
Red Beauty	<1	5 (10)		25 (50) [75% foliage remaining on plant]
Ruth Alexander	2 (1)	5 (10)	2 (1)	40 (10) [70% foliage remaining on plant]
Simplicity	<1	<1	10 (20)	60 (20) [60% foliage remaining on plant]
St. Patrick	<1	<1	10 (5)	40 (20) [90% foliage remaining on plant]
Sweet Inspiration	<1	<1	10 (15)	5 (5) [80% foliage remaining on plant]
Sweet Surrender	<1	1 (10)	10 (5)	20 (10) [90% foliage remaining on plant]
The Pilgrim	<1	20 (50)	1 (2)	20
Trandescant	<1	1 (1)	10 (5)	30 (25) [85 % foliage remaining on plant]
Veterans Honor	<1	<1	15 (25)	4 (10) [80% foliage remaining on plant]
Wenlock	10 (15)	20 (30)	5 (2)	20 (10) 70% [foliage remaining on plant]

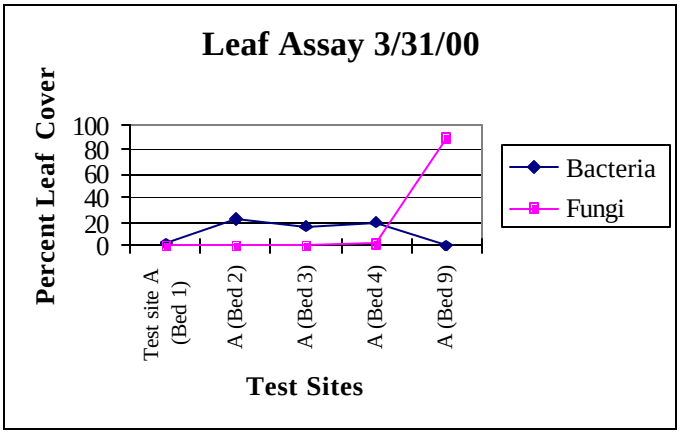
Changes in Levels of Soil Microbial Organisims

Soil samples from Test site A taken on March 31 (pre-compost tea application) indicate the strong presence of both fungi and bacteria in both active biomass and total biomass quantities (Table 5). However, the absence of adequate levels of predatory organisms and nematodes results in low availability of nitrogen to the plants. Later in the season, fungal levels are higher and bacteria and nematode levels are higher as well resulting in more nitrogen availability to plants. Interestingly, despite the similarity in bacteria and fungal levels in the test beds and the conventional bed, the compost tea treated beds have higher levels of available nitrogen than the conventional bed suggesting the compost tea is providing necessary nematodes and predatory organisms. This is not entirely explained by compost tea. Further soil sampling in future seasons in test and conventional beds pre-treatment and at the end of the season will help clarify the microbial activities occurring on the two differently managed sites.

Table 5. Condition of microbial organisms in pre-compost tea and mid-trial soils.

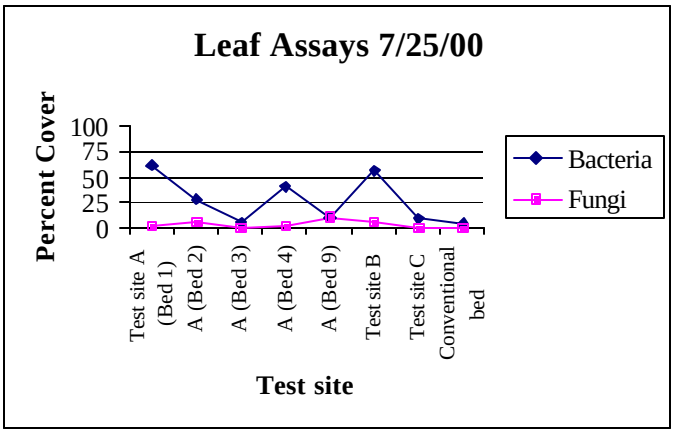
Test Site	Pre-tea sample, March 31, 2000	Mid-season sample July 25, 2000
Test Site A	Excellent active bacteria biomass, but total bacterial biomass too high. Excellent active fungi biomass but total fungal biomass too low. Low nemaotdes Low available N to plants from predators	Lower active bacteria biomass than before but improving total bacteria biomass. Much higher active fungal biomass but some beds too low. Low to moderate nematode presence but ok since fungal biomass is high. Need more diversity. Good N availability to plants in test beds.
Test site B	No soil test performed	
Test site C	No soil test performed	
Conventional bed	No soil test performed	Active bacteria biomass comparable to test beds Total bacteria biomass comparable to test beds Active fungal biomass good Total fungal biomass comparable to test beds. Lower N availability to plants than in test beds suggesting low numbers of nematodes and predators.

Leaf Assays



Assessment of bacteria and fungi coverage on the leaf surfaces was conducted twice during study period. The first leaf sampling occurred prior to the initial soil drench application (March 31). Most beds showed to very low coverage on the leaf surface of both bacteria and fungi. Ideally, more surface coverage by bacteria and fungi (the beneficial types found in compost tea) is desired. Bed 9 in Site A was an anomaly, with nearly 90% coverage of fungi. (This extreme measurement may be a sampling error.)

By the end of July, bacteria levels on leaf surfaces of test site plants had increased from less that 20% to as high as 60% total leaf surface coverage. Several samples, however, did indicate less than 5% coverage suggesting poor leaf surface coverage with tea applicator. However further foliage sampling throughout the test period would provide a more accurate picture of the total coverage of foliage following tea applications.



Conclusions and Recommendations for further studies

The Woodland Park Rose Garden contains a large collection of rose varieties, each varying in its resistance to disease. Developing a scientifically defensible protocol to treat a broad range of plant sensitivities to black spot, rust, powdery mildew and other diseases with compost tea is a large undertaking requiring controlled-chamber conditions and dedicated personnel. The compost tea trials at Woodland Park provided an opportunity to conduct an observation-based test of compost tea on a portion of the rose collection. Results from this trial were not intended to be interpreted as scientifically rigorous, but are strictly based on visual assessment of plant responses to regular applications of tea.

The outcome of the rose garden compost tea trials suggests that roses in the trial sites did not benefit visibly from the tea treatments. It is important to note, however, that the plants did not likely decline from the tea. The varieties that exhibited the worst symptoms of black spot may have been varieties that have little resistance to the disease and have in the past been aided by fungicide applications to overcome seasonal infections. Controlled greenhouse tests of each rose variety would be required to determine the sensitivity of each variety to blackspot and other diseases.

By comparison, the University of Washington rose garden compost tea trial study was more successful in controlling the spread of rose diseases. This may have been due to a more fungal-dominated source of compost and weekly rather than bi-weekly tea applications. Not only did plants probably benefit from the additional inputs of compost tea, but may have also benefited from the additional hydration they received along with the tea. It was noted that two varieties that are particularly prone to black spot, Chicago Peace (also in Woodland Park Rose Garden) and Summer Dream, did show advanced degrees of blackspot disease. The University is planning to remove several of the more disease-prone varieties and to replace them with more disease-resistant ones.

Similarly, at Jackson Golf Course, the protocol was adjusted during the study to apply tea once a week rather than once every two weeks. The more frequent applications there may also have benefited the plants in both microbial activity and hydration.

Finally, prolonged use of fungicides in the gardens over the years may have left residues in the soil that will require several seasons of soil amendment with compost tea and compost top-dressing to restore the normal balance of organisms required in the soil. While this study began to address some of these issues, further studies are needed to fully uncover compost tea's effect on rose plants.

Further Study Suggestions

We recommend that a second season of compost tea applications be carried out at the rose garden. Continuing the study on Sites A, B and C to take advantage of any soil improvements that occurred during the first trial study. In addition, there a control site should be selected in conventional beds for visually assessing and comparing the extent of diseases in treated and control plants.

Other recommendations include:

- Inoculate study sites with mycorrhizal fungi at the beginning of the season through spore additions to top-dressing compost.
- Begin compost tea applications to soil and stems prior to leaf emergence in the spring.
- Brew tea from a mixture of several types of compost to ensure wide diversity of organisms in the tea. Types of compost include fruit-waste compost, green yardwaste compost, vermicompost, dairy farm compost, and zoo doo.
- Include a six-week rotation of top dressing with compost to protocol.
- Conduct monthly nutrient level analysis of soil including pre-study baseline.
- Collect soil samples at the beginning and end of the season for microbial activity tests.
- Conduct monthly foliage assays to ensure proper coverage of compost tea on leaf surface, and to monitor existence of desired bacteria and fungal organisms.

3. Jackson Park Golf Course

Introduction

When the City adopted its strategy of reducing the use of pesticides on City landscapes by 30%, consideration turned to City-owned golf courses. Seattle's golf courses represent a significant proportion of the city-managed landscape. The amount of turf involved, the extent of their use as well as the management practices required to meet expected standards of play leads to the use of significant quantities of chemicals.

Since the golf courses utilize significant quantities of fungicides, a reduction in their use on City courses would represent a major contribution to the City's overall chemical reduction goals. City officials met with the managers of the City-owned courses to determine their interest in undertaking trials to test the effectiveness of compost tea on disease suppression on golf course greens. Discussions with Municipal Golf of Seattle, the organization contracted to manage Seattle's golf courses, led to the selection of Jackson Park Golf Course in northeast Seattle, as the focal point for the field trials.

Negotiations took place with Jackson Park Golf Course management to determine the scope of the field tests, focusing on the following criteria:

- That sites would include greens that receive normal play to ensure testing of compost tea effectiveness under realistic conditions;
- No surface-applied solid compost would be added as top dressing to the greens due to concerns that the compost would retain water and adversely effect green conditions; and
- The golf course management would maintain decision-making control over when to treat any disease outbreak that may occur on compost tea greens in an effort to avoid deterioration or loss of greens due to disease or nutrient deficiencies.

These discussions led to an agreement to use compost tea on Green 1 and Green 15 located on the 18-hole course, a small section of the main practice putting green (approximately one-third of the putting green divided from the larger section by a collar) a temporary green on the 14th hole, and a fairway section on the 14th hole that slopes down to a pond. The remaining greens received another trial program, while the short-nine course received the conventional management regime normally followed by Jackson. Based on this agreement, protocols were developed for the application of compost tea.

The compost tea trials at Jackson Park Golf Course represented field trials rather than scientific experiments. The objective was to manage certain areas of the course (the designated compost tea greens) with compost tea. As part of that requirement, compost tea application protocols were developed for approval by both the City and Jackson Golf Course.

Methodology

This section of the report outlines the methodology developed and the results of the compost tea applications to the three greens and a portion of the 14th fairway at Jackson Park Golf Course. The report provides information on activities for each specific green as well as the fairway.

The major goal of the study was a reduction in the use of chemicals applied at the golf course as a result of the use of compost tea. The study hoped to achieve the following objectives through the application of the tea:

- Reduction of the incidence of disease;
- Restoration of beneficial organisms to the soil; and
- Maintenance or improvement in turf health including turf color and density and green playability.

Achievement of these objectives would support the hypothesis that a compost tea recipe applied on a regular basis will be effective in maintaining turf quality on golf course greens and fairways. Table 6. lists the original application protocol developed to test this hypothesis.

The protocol development drew on the limited information on compost tea applications on various landscapes. There is very limited information on the effectiveness of compost tea applications on golf courses and experience with compost tea on poa annua turf greens in the northwest is virtually non-existent. Concerns were voiced that application of tea would provide insufficient nutrients and cause deterioration of turf quality. These concerns over turf response to the compost tea led to the agreement that the Course Superintendent would evaluate disease conditions and determine if and when to apply a fungicide to treat the disease and fertilizer to boost nutrients in the soil.

Originally the protocol called for application of a soil amendment of compost mixed with sand (30% compost/70%sand) for use as top-dressing. The amendment would have been applied to all greens receiving the compost tea during the aerification process. Supplementing the existing soil with compost was expected to stimulate microbiological activity. This soil supplementation did not occur for two reasons. People voiced concerns that adding organic matter to greens could lead to greater moisture retention in the soil, impeding drainage. In addition cultural practices were modified and the greens were not aerified during the late spring, eliminating that opportunity to add compost amendments.

Tea applications began in early July. Delays in the development and agreement on the application protocol as well as a decision to initiate the tea trials at the conclusion of a July 4th tournament led to the 6th July start.

Table 6. Program Protocol developed for Jackson Golf Course

Program	Protocol
First Application	July 6, 2000
Application Schedule	Every two weeks from the start date through until the end of the year.
Compost Tea Application Program	Compost tea mixed with a catalyst that includes kelp and molasses. For at least the first two months additional products will be added to the tea to stimulate plant growth. The products are Blend and Lase. Blend and Lase will be added directly to the tea during the brewing process. Tea will be sprayed on the greens using a hand boom. Tea applications will be carried out after mowing is completed in the morning. The fairway applications will occur at the same rate as programmed for the greens to ensure adequate coverage and an effective soil drench. During the first tea applications and until necessary no additional nutrients or fertilizers will be added. This will provide an opportunity to observe the response of the turf to the compost tea. Decisions on using fertilizer and on the appropriate product will be made based on the results of the tissue analysis and soil test. Any fertilizer application rates will be those of the manufacturer. Tea will be applied at a rate of between 0.5 and 1 gallon of tea per 1,000 square feet (10 gallons of diluted tea with supplements per 1,000 square feet). These rates take into account the minimum application rate of 5 gallons per acre recommended by the Soil Food Web and higher rates used by private contractors on turf in the northwest. This rate will ensure adequate foliar coverage with tea and is expected to give positive results on the turf. Tea will be applied to the fairway at a rate of 1 gallon of tea per 1,000 square feet. The fairway application aims ensure an adequate soil drench to build up microbial populations in the soil and improve soil health. Lase and Blend will be added to the tea prior to brewing at a rate of one quart each per 50 gallons of tea. The total area of greens and fairway is approximately one acre. The application rate is thus one quart per 50 gallons of tea per acre. This rate is consistent with the manufacturer's recommendation of one to two quarts in 5 to 50 gallons of water per acre. (Product labels for these appear in A)
Monitoring Activities	Chemical soil tests will be taken every three months on the test greens to observe changes and respond to potential problems or deficiencies. Microbiological soil test on both test and control greens and the 14th fairway after six weeks (mid-August) and in December. Turf tissue tests on greens' clippings every two weeks. Collection of clippings will take place on the days of compost tea applications, after mowing and before tea application.

Compost and Compost Tea

Brewing quality compost tea requires the use of high quality compost. High quality compost refers to compost that is high in microbiological activity and which does not contain root feeding nematodes or other plant-destructive organisms. This study selected three sources of high quality compost for tea brewing. The study obtained compost from Growing Solutions' Hood River Oregon source, the Inter-Bay

P-Patch, a Seattle gardening and compost organization and Grounds Up, a private Seattle supplier. Both Seattle sources underwent food web analysis from the Soil Foodweb Inc. in Corvallis, Oregon. Tests indicated active microbiological activity and determined it appropriate for the planned turf applications. The tests recommended that the P-Patch source receive extra drying time before use (this was done) and recommended specific additives to stimulate microbiological activity during the brewing process. Tea was brewed using a Micro Brewer manufactured by Growing Solutions. The 50-gallon Micro Brewer was purchased by the City of Seattle for the compost tea field trials. For each brewing cycle water was filtered to remove chlorine to avoid morbidity in microbial populations.

Additives

Based on recommendations from the Soil Food Web, Inc. two products were added to the tea, Lase and Blend. Blend is a complex soil conditioner containing a mix of organic acids and bio-stimulants designed to stimulate microbiological activity in the soil. Blend is rated a 5-0-0, containing 5% urea nitrogen, 0.1% chelated iron, 0.05% chelated manganese and 0.05% chelated zinc.

Lase is a formulation of nitrogen and enzymes with an organic acid base designed to stimulate the aerobic decomposition of organic residues into humus and increase the availability of nutrients. It accelerates the decomposition of soil organic matter in thatchy situations. Lase is rated 24-0-0 and contains 24% total nitrogen (5.75% ammoniacal nitrogen, 5.75% nitrate nitrogen and 12.5% urea nitrogen)

At each brewing one quart of each of Lase and Blend were added to the tea prior to initiating the brewing process. Also, as part of each brewing process a catalyst including North Atlantic sea kelp and organic molasses was added to help stimulate microbiological activity. The catalyst was provided by Growing Solutions with the purchase of the brewers.

On the 14th fairway the study added a product called Vitol to the compost tea mix. One quart of Vitol was added to 75 gallons of diluted tea. The product was added to the tea only after completion of the greens' application. Vitol is a nutrient blend used in establishing new turf and for supplying phosphorus during periods of active root growth. Vitol (6-12-3) contains 6% total nitrogen, 12% available phosphate and 3% soluble potash. The product data sheet for Vitol appears in Appendix C.

Data Collection

During the study, soil and tissue samples were analyzed to monitor conditions on the study greens. The effort began with three sources of baseline data as part of this effort. Jackson Park provided copies of a soil chemical analysis completed on May 22, 2000 and the study undertook a soil microbiological analysis on May 28th and a tissue test of test greens prior to the first application of tea on July 6, 2000.

The study completed two soil chemical tests, one on August 22nd and a final one on September 25th (following aerification which took place on September 21st). The study also completed tests of plant tissue (turf collected after mowing). The baseline test occurred on July 6th prior to application with two additional tests taken on July 20th and August 11th.

In addition the study carried out a pre-study microbiological soil test. The results of that test indicated that the greens were out of balance with regard to the ratio of fungi to bacteria indicating a need for fungal foods, thus the addition of LASE to the mixture early in the process. The tests also indicated low nutrient cycling indicating a need for the addition of additional nutrients such as nitrogen, phosphorus and sulfur. LASE, BLEND were added to address these deficiencies.

Changes in Protocol During Study

The goal of this tea trial was to manage the greens using compost tea so that the appearance and quality of play would not be compromised. As a result, the study needed to be responsive to the pressures the course received from its clients and ensure that turf quality did not deteriorate. This approach led to modifications in the protocols in response to field observations in an effort to manage the greens and maintain turf quality.

Deterioration of turf quality (turf yellowing, disease) especially on the small putting green as well lead to questions whether compost tea alone could adequately maintain desired turf quality. Observations made in the field one month into the study led to the following conclusions:

- The compost tea recipe that was applied according to the protocols was not effective in maintaining turf quality consistently on all the greens.
- The two-week time period between applications appeared too prolonged to ensure adequate provision of nutrients and beneficial organic material to the turf. As a result applications increased from once every two weeks to once every ten days, starting in August, to respond to turf needs.
- The application of the tea along with the additives did not build adequate balance of the soil organisms quickly enough. Achieving greater soil balance and improved nutrient cycling would have required more intensive management of the greens, something that was outside scope of this study and of the time availability of course staff.

These observations led to a modification in overall application protocols. Applications increased from once every two weeks to once every ten days. The focus also moved from following established protocols, which were not working effectively, to taking into account the situation at each green and devising protocols to respond to field reality. This led to more responsive applications and supplemental fertilization in an effort to prevent disease and maintain turf quality using compost tea and fertilizers while foregoing the use of fungicides to the extent possible. In discussing the results of the applications, this report focuses on each specific green, recognizing the unique physical and chemical characteristics of each green and their differing response to the tea applications.

Other changes in the protocols occurred as result of modifications in management practices. The original protocols established greens 8 and 6, as well as the larger section of the practice putting green, as the control greens for the study. However, as the study began these greens began to receive treatment with Floratine, and no longer served as control greens. For the Floratine monitoring program, soil test results were obtained for the putting green, as well as greens 2, 4 and 14. Given the loss of these control sites, a decision was made to select greens on the short-nine course for comparison purposes and these greens were monitored by the City's Pesticide Reduction Coordinator.

Prior to initiation of the tea applications all compost tea greens received an application of fungicide on May 26th. . The baseline soil chemical tests for all greens occurred on May 22nd, several days prior to this fungicide.

Monitoring Data Collection

The City's Pesticide Reduction Coordinator carried out the monitoring of the compost tea greens (as well as the greens treated with Floratine and the short-nine control greens) every two weeks starting in mid-July. The monitoring sheets used in the program appear in Appendix D.

Monitoring Results

The report provides the results of the periodic monitoring. Reports on green conditions (turf color, density, degree of disease) are based on monitoring sheets filled out by the City's Pesticide Reduction Coordinator over the course of the study. The forms were used on all monitored greens at Jackson Park, which included the remaining greens on the 18 hole course. These received nutrient applications using a commercial product line called Floratine, and the greens on the short-nine course, which received conventional treatment and were used as a control for observations about the effectiveness of the study.

The monitored greens included the following:

- For compost tea: greens 1 and 15, as well as the small putting green;
- For the Floratine system; greens 2,4, and 14 as well as the large putting green ;
- For conventional treatment (the control) the short-nine course: greens 1 and 3.

This reports includes the monitoring results from the compost tea greens.

This report does not include information about the compost tea treatments applied to a temporary green on hole 14. Tea applications began on that green in July as an additional test site but an oversight led to little to no irrigation of the green during the summer and die off of the turf. Tea applications took place later in the summer in an effort to revive the green after replanting. Given the dramatic change in conditions and the fact the green received no play at all, monitoring of this green did not continue.

Green 1

Green 1 covers an area of approximately 7,000 square feet and the study established a target of 70 gallons of tea per application, (this rate was not reached during the first application due to equipment calibration problems). Applications in later September, October and November sometimes exceeded that amount in an effort to strengthen the turf prior to winter. Tea was applied using a hand boom. Table 7 lists the dates of application, the amount of tea applied. All monitoring was carried out by the City of Seattle to ensure impartiality of the results.

During the course of the field trials Green 1 required two applications of additional fertilizer to improve color and turf density. Jackson Park staff indicated that the green typically suffers from thinning and this year was no exception. Staff did indicate that disease problems seemed to be greater in past years. During the first half of the season Green 1 received four applications of fungicide while only two during the second half of the year. Although this cannot necessarily be attributed to the compost tea, further testing of its disease whether fertilization occurred and indications of issues or concerns about turf quality. The 24 October fungicide application was done as a preventative measure to ensure no disease on the greens upon entering the dormant season.

Table 7. Field Application Log for Green 1.

Date of Application	Amount Compost Tea Applied	Interventions	Observations on Turf Quality
July 6, 2000	50 gallons	None	Good to fair
July 20, 2000	70 gallons	None	Turf color and density is fair to good
August 3, 2000	70 gallons	None	Turf color and density fair to good. No sign of disease
August 11, 2000	70 gallons	None	Turf color fair to good but density slightly lower (some thinning). No disease.
August 22, 2000	70 gallons	Course staff applied 18-9-18 Scotts with iron at 3.75lbs. /1,000 sq.ft. on 18th August	Turf color fair to good but density slightly lower (some thinning). No disease.
September 1, 2000	70 gallons	A product description should be inserted for this product close to this reference also add a label at the end of report microbes (0.25 lbs) added to the tea to provide rhizobacteria to fight fusarium and pithium.	Turf color remains fair to good while green does show signs of thinning.
September 7th (supplemental application)	5 gallons of concentrate spot application on areas of disease	Course staff applied 18-9-18 Scotts with iron at 3.12/1,000 sq.ft. on 8th September.	Active symptoms of fusarium but infestation is light. Color and density remain fair to good. No fungicide application required.
September 12th	70 gallons	Green was aerated, seeded and top-dressed. Turf-Tech Bio added	With aerification conditions on the green difficult to determine. Staff reported some spotting resulting from the spot applications of tea.
September 21st	70 gallons	Turf Tech Bio* added to mixture	Good to excellent color with continuing fair density. Some light fusarium patches but very light.
October 15th	70 gallons	Staff treated the green with Bayleton at 2.1 lb. Per 1,000 square feet on 10/7/00 for anthracnose.	Some yellowing but fair to good color while density improved. No active disease present.
October 24th	70 gallons	PCNB applied at 5.1 lbs/1000 square feet	Some disease but color and density improved
November 3rd	150 gallons hand application	None	Improved color and density – no disease
December 1st	150 gallons. Hand application	None	Color and density excellent. No disease.

Turf Tech Bio consists of multiple varieties of dormant, beneficial microbes in a powder form, which is mixed with liquid, for spray application or injection into irrigation systems. (see Appendix C.)

Results

Table 8 indicates the results of soil samples taken on Green 1 during the testing period and are compared against a baseline test taken on May 22nd. The most interesting result occurred during the August 24th soil test. The nitrogen level (ppm of NO3) registers 0.0, down from 7.0 from the baseline. This occurred at the same time that the estimated organic N release increased from 54 to 72 lbs per acre. This result appeared even after an application of fertilizer by Jackson on August 18th as noted in Table 7 above. This significant decrease caused concern and led to a decision to increase fertilization, even though green appearance was fair to good with only limited loss in density.

.

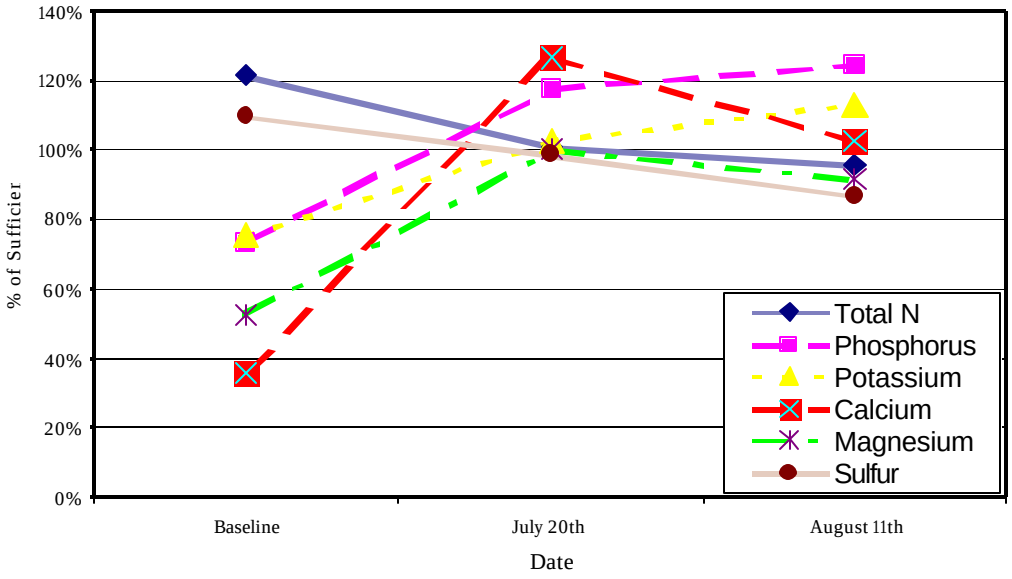
Table 8. Soil Chemical Test Results for Green 1

Test	Average Target Level	Baseline May 22nd	August 24th	September 25th
C.E.C (Meq/100)	> 10	4.9	8.2	6.1
pH	6.5-7.0	6.5	6.6	6.3
% Organic matter	0.8	1.7	2.6	1.9
Estimated organic N release (lbs/acre)	N/A	54	72.0	58.0
Nitrogen (ppm NO3)	5.0	7.0	0.0	9.0
Phosphorus (ppm)	50	82	119	95
Potassium (ppm)	135	103	125	97

Nitrogen levels increase to 9.0 ppm after the 11th September aerification while both the percent organic matter and estimated amount of organic N release showed declines

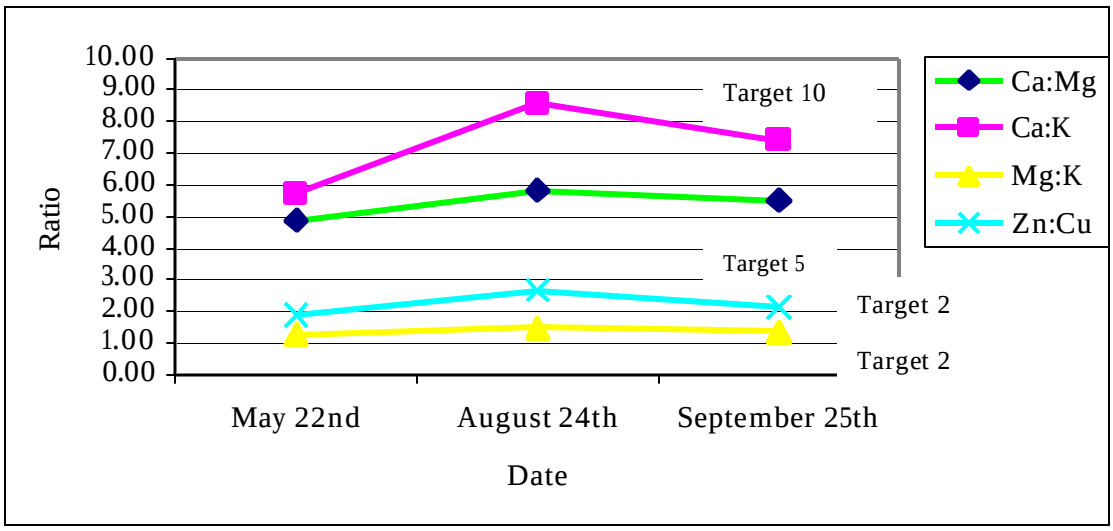
Figure 2 illustrates the results from tissue samples taken from the green prior to applications. The benchmark established is percentage of sufficiency. Results indicate no appreciable problems with nitrogen, even though during this time some loss of color and thinning occurred on the green. The tissue samples do show lesser variability around the 100% of sufficiency line with the applications of compost tea. These sufficient nitrogen levels occurred at the same time that the soil chemical tests indicated low nitrogen. One possible explanation was that nitrogen was tied up in the soil and did not appear in the test results. This nitrogen tie-up could have resulted from increased microbiological activity in the soil. Another possible conclusion is of laboratory error since all samples sent to the laboratory on the day in question showed nitrogen levels at 0.0 ppm. In any case after the aerification and the fertilizer application of September 8th, N levels increased again and no serious problems were identified on this green.

Figure 2. Tissue Sample Test Results for Green 1



Tissue samples also indicate significant increase in calcium in the turf. Calcium can often be a limiting element in Northwest soils. A look at soil chemical ratios in Figure 3 indicates ratios somewhat closer to established targets after compost tea applications, especially with regard to the Ca:K ratio. This ratio does fall off however during the latter test. The major exception is the Fe:Mn ratio which was which was extreme in most samples, with greatest distortions in the baseline sample (target 1:1; baseline 29:1, test results between 35 and 20:1, respectively).

Figure 3. Nutrient Ratios for Green 1 Compared to Established Targets



Comparisons with Floratine Sites.

Data are available from soil tests conducted on greens that received the Floratine treatment. Some of the monitored green receiving Floratine treatments were located in close proximity to compost tea greens and can serve as an illustrative point of comparison regarding turf and soil response to the two different treatments. For example, in this case, soil chemical results from Green 2 (treated with Floratine) can be compared with the soil chemical results from Green 1 (compost tea). Results for Green 2 are derived from soil collected in early November, while the Green 1 samples were taken in late September. Both greens had received respective treatments for three months or more. Table 9 shows the results. In general the Floratine treated green shows somewhat better nutrient balance and results more consistently with the targeted range established for golf courses in the Northwest.

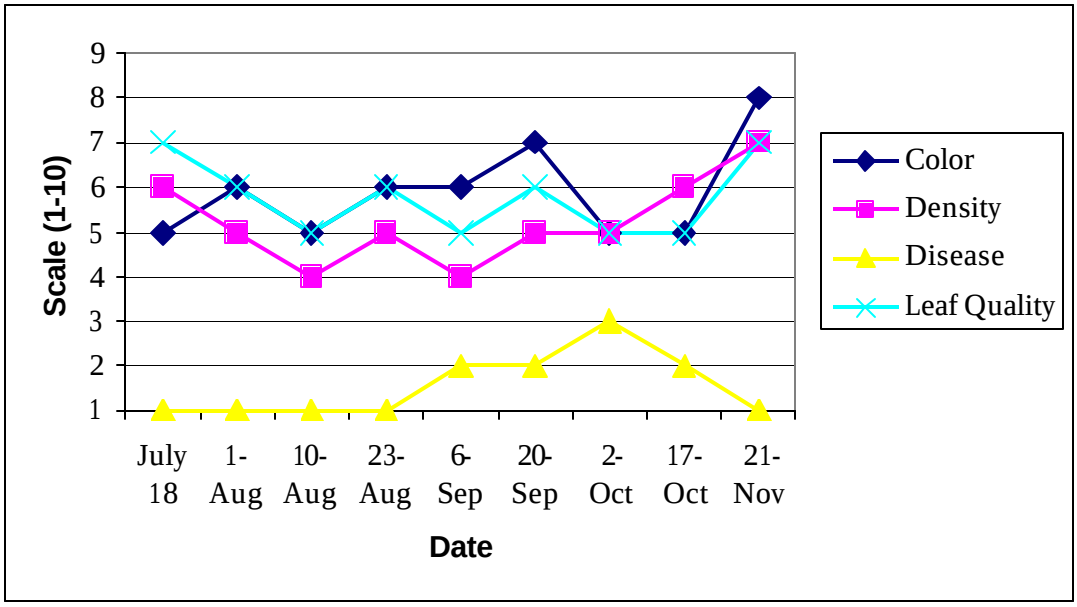
Table 9. Comparison of Results between Greens 1 and 2

Description	Green One (Tea)	Green Two (*Floratine*)	Target Ranges
C.E.C.	6.1	6.3	5.0-10.0
pH	6.3	6.7	6.0-6.5
% organic matter	1.9	1.8	1.5-3.0
Ca:Mg Ratio	5.5	7.0	8:1
Calcium %	58.7	72.4	65-75
Magnesium %	17.8	17.1	10-15
Potassium %	4.1	5.2	4-8
Sodium %	1.8	1.5	1.5
Hydrogen %	13.1	3.7	0-5

Disease did affect both greens, however. Green 2 (Floratine) received a treatment of Fore and Heritage on 1st September, a treatment of Fungicide IX on 13th October and PCNB on 24th October. Green 1 received a treatment of Bayleton on 7th October and PCNB on 24th October.

Figure 4 depicts the results of the monitoring that occurred on Green 1 throughout the study. These results track color, density, leaf quality and disease. The monitoring was done on a one to nine scale. For leaf quality, color and density the scale has the following interpretation: 1=poor, 5=average and 9=excellent. For the disease monitoring 1= none, 5=moderate and 9=heavy. For most of the year Green 1 showed moderate to good density, good color and light to moderate disease.

Figure 4. Green 1 Monitoring



No specific conclusions can be drawn about the effectiveness of compost tea on the performance of Green 1. However several observations are warranted.

- Jackson Park staff noted that disease problems on Green 1 were less severe than noted on other greens on the course. Staff also noted that the level of disease on Green 1 apparently was less prevalent this season than during other years. However this cannot be necessarily attributed to compost tea, given the short application period. Further observations are warranted.

- Compost tea appeared to contribute to an increase in organic matter in the soil. Tests indicate an increase in soil organic matter that declined again after aerification and the addition of sand to the greens. However the amount of time available to track soil organic matter was insufficient to draw generalities on the overall seasonal increase in organic matter. Further trials may address this.

- Because of the nature of the test, Jackson staff decided against using fungicide until they felt that the disease was active enough to hurt the overall quality of the turf if left untreated. The assumption is that the Course would have applied an earlier fungicide treatment to be consistent with treatments received by non-compost tea greens. Treatment was curative rather than preventative. This practice of treating the problem in a curative manner rather than

using chemicals preventatively resulted in fewer applications of chemicals. This result does not address the effectiveness of compost tea but does point to possible management options that could be employed to achieve City pesticide reduction goals.

Green 15

Green 15 has an area of approximately 12,000 square feet and the study established a target of 120 gallons of tea per application. Throughout the study this rate was generally achieved (except for the first application where calibration problems arose). Table 10 provides the dates of application, the amount of tea applied, whether fertilization occurred and indications of issues or concerns about turf quality. Again, all monitoring was carried out by the City of Seattle to ensure impartiality of results. During the course of the field trials Green 15 received fertilization to boost turf strength in an effort to control disease. From July through September the turf maintained good color and density. Disease did affect the green but Jackson staff felt that the disease was not a sufficient problem to warrant treatment until later in the year. Staff applied fungicide to the green on October 13th to ward off a disease outbreak.

In early October the Green 15 began to show some color fading. The cause of this loss of color cannot be determined but appears to have become more pronounced following the 15th October fungicide application. This fading could be attributed to the loss of microbial life that occurred with the application of the fungicide although no data are available to confirm this. The application of fungicide occurred based on a needs assessment by Jackson staff. There was no time available to collect samples prior to the application. It is also possible that fading would have occurred due to nutrient problems, although little evidence exists to show stress. However, despite the early fall disease problems the green looked and performed well for much of the season. Fungicide applications were only required late in the year and a second application covered only one-half of the green. In comparison, the short-nine Greens 3 and 6 (the controls) received fungicide treatments on August 14th, September 1st, October 24th and November 27tt, 2000.

Table 10. Field Application Log for Green 15.

Date of Application	Amount Compost Tea Applied	Interventions	Observations on Turf Quality
July 6th	83 gallons	None	Very good color; density good to excellent with no disease
July 20th	120 gallons	None	Very good color; density good to excellent with no disease
August 3rd	120 gallons plus some extra soil drenching on disease patches	Corn gluten fertilizer applied at a rate of 15 lbs per 1,000 sq. ft. (0.15 lbs N); soil tea drench of disease patches.	Very good color; density good to excellent. Some light rings of yellow patch appeared.
August 11th	120 gallons plus some extra soil drenching on disease patches	Some extra soil drenching with tea on disease spots. Fertilization with granular product at a rate of 0.25 lbs N/1,000 sq.ft.	Still some disease but minor. Turf continues to look good with good to excellent density
August 22nd	120 gallons plus some extra soil drenching on disease patches	Some extra soil drenching with tea on disease spots	Disease light. Some polka-dotting of green from the inconsistent fertilization possibly from the corn gluten
September 1st	120 gallons	Turf Tech Bio microbes (0.25 lbs) added to the tea to provide rhizobacteria to fight disease. Some extra soil drenching on disease patches	Turf density and color are good to excellent. Yellow patch still exists but not as pervasive as on the 11th. Disease requires monitoring.
September 7th (supplemental application)	5 gallons of concentrate spot application on areas of disease	None	Active symptons of fusarium and yellow patch on green with infestation moderate. No fungicide application required at this time. Color and density both good but some decrease in density from last application.
September 12th	120 gallons	Green was aerated, seeded and top-dressed. Turf-Tech Bio added.	With aerification, conditions on the green difficult to determine. Staff indicated active disease present when aerified and blotching where tea was added to disease patches.
September 21st	120 gallons	Turf Tech Bio added to mixture	Good to excellent color with continuing fair density. Some fusarium patches but very light.
October 15th	120 gallons	Staff treated the green with Bayleton at 3 lbs per 1,000 sq. ft. on 13th October.	Green color shows fading and density remains moderately good. Disease has been suppressed.
October 24th	120` gallons	None	Green is faded with weak looking turf. Turf requires a boost. Some fusuarim but moved from south to north side
November 3rd	200 gallons	October 30thth . Fertilized with 18-9-18 with iron at 2.5 lbs per 1,000 sq. ft.	North end paler than the south end. Disease coverage at north end around 60%
November 8th	150 gallons	None	Disease still active on the north side of the green. Color still pale since the fungicide application.
December 1st	300 gallons	16 November PCNB applied on north half of green at rate of 3.8	Some disease was still apparent. Green still has pale color.

		lbs/1000 sq.ft. Disease patches received a tea drench.	

Results

For most of the study period, Green 15 showed positive results from the compost tea and limited fertilizer applications. Both turf density and color remained strong throughout most the early period of the study. Problems of disease began to affect the Green in late summer and early Fall, finally requiring treatment in October.

Table 11 indicates the results of soil samples taken on Green 15 during the testing period and are compared against a baseline test taken on May 22nd. On August 24th , the nitrogen level (ppm of NO3) registers 0.0 (as in Green 1) down from 5.0 from the baseline only to rebound to 10.00 ppm on September 25th . Table 10 indicates that Green 15 received a corn gluten and granular fertilizer in the first half of August. This fertilization did not appear to affect the amount of nitrogen measured in the soil nor did it lead to an increase in the estimated organic nitrogen release, which fell slightly from 50 to 48 pounds per acre. Tests also do not show an increase in the percentage of organic matter in the soil. That percentage remained fairly constant throughout the study period at 1.5%. This result differs markedly from what the study observed on Green 1. The largest variability in results occurred in soil nitrogen levels following core aerification. Nitrogen increased from 0.0 ppm to 10.00, a result consistent with what was observed on Green 1.

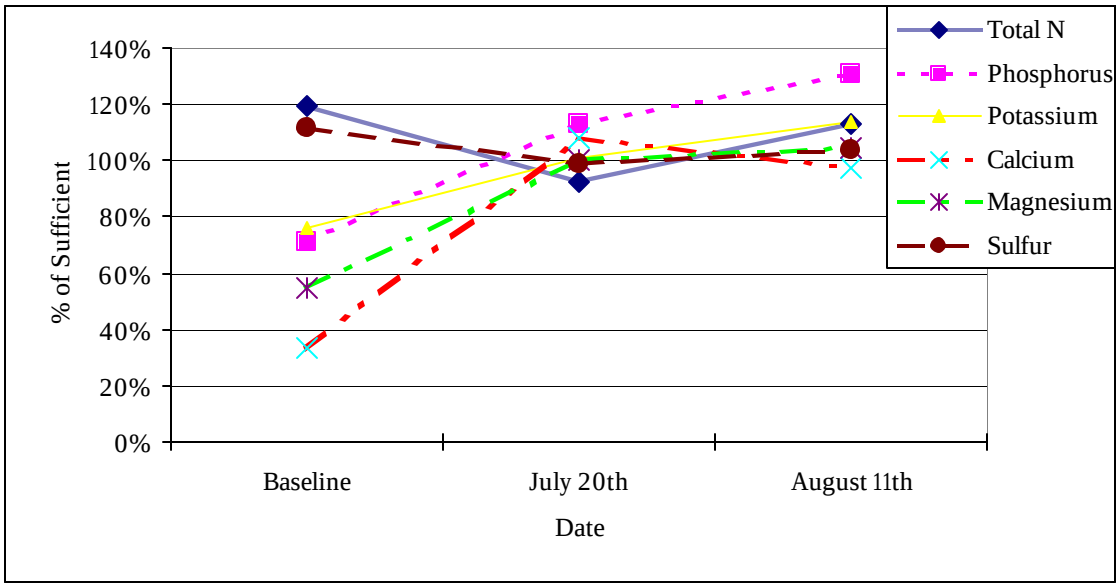
These soil results contrast with the results from tissue samples as well as the field observations, which showed good turf color and density throughout the period of the study. Figure 6 shows the results from the tissue samples. Results indicate that nitrogen levels dropped from the baseline levels but remained near or above 100% of sufficiency. At the time that soil nitrogen was registering zero, nitrogen in sample leaf tissue was at a level of 100% sufficient indicating adequate uptake of nitrogen. At this same time Green 15 had good to excellent color and density.

Table 11 Soil Chemical Test Results for Green 15

Test	Average Target Level	Baseline	August 24th	September 25th
C.E.C (Meq/100)	10	7.1	6.3	5.6
pH	6.5-7.0	6.2	6.0	6.3
% Organic matter	0.8	1.5	1.4	1.5
Estimated organic N release (lbs/acre)	N/A	50.0	48.0	50.0
Nitrogen (ppm NO3)	5.0	8.0	0.0	10.0
Phosphorus (ppm)	50	52	49	71

Potassium (ppm)	194	113	142	74

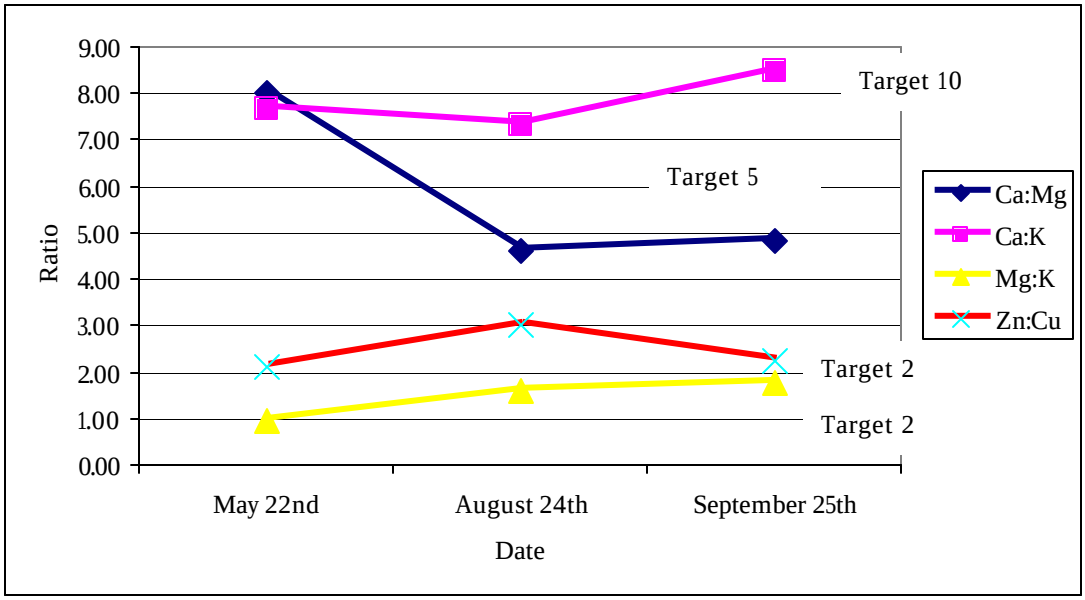
Figure 6. Tissue Sample Test Results for Green 15



In general the results in Figure 6 show improved nutrient balance of measured nutrients in the tissue from the pre--tea baseline, with the possible exception of phosphorus, which moved from below to above sufficient levels.

For soil nutrient ratios on Green 15 Figure 7 indicates ratios closer to established targets after the tea applications with both test results showing improvements over the baseline. The variability across time is more pronounced in Green 15 than in Green 1 but with movement toward targets. The September 25th test especially resulted in ratios very close to established targets, indicating generally good nutrient balance. As in the case of Green 1, the Fe:Mn ratio was extreme in most samples and is not included in the chart for reasons of scale (target 1:1; baseline 49:1, test 38 and 37:1 respectively). No soil samples were available in late October or November when deterioration of turf quality on Green 15 was observed.

Figure 7. Soil Nutrient Levels for Green 15 Compared with Established Targets



Comparisons with Floratine Sites.

Data are available from soil tests conducted on greens that received the Floratine treatment. In table 12 soil chemical results from Greens 4 and 14 (treated with Floratine) can be compared with the soil chemical results from Green 15 (compost tea). These greens are in close proximity on the course. Results for Greens 4 and 14 are derived from soil collected in early November, while the Green 15 samples were taken in late September. The three greens received their respective treatments starting in July and carrying through until November. Table 12 shows the results. Again, the Floratine treated greens shows somewhat better nutrient balance and results more consistently within the range established for golf courses in the Northwest. Green 15 shows low levels of potassium and above range results for sodium and hydrogen.

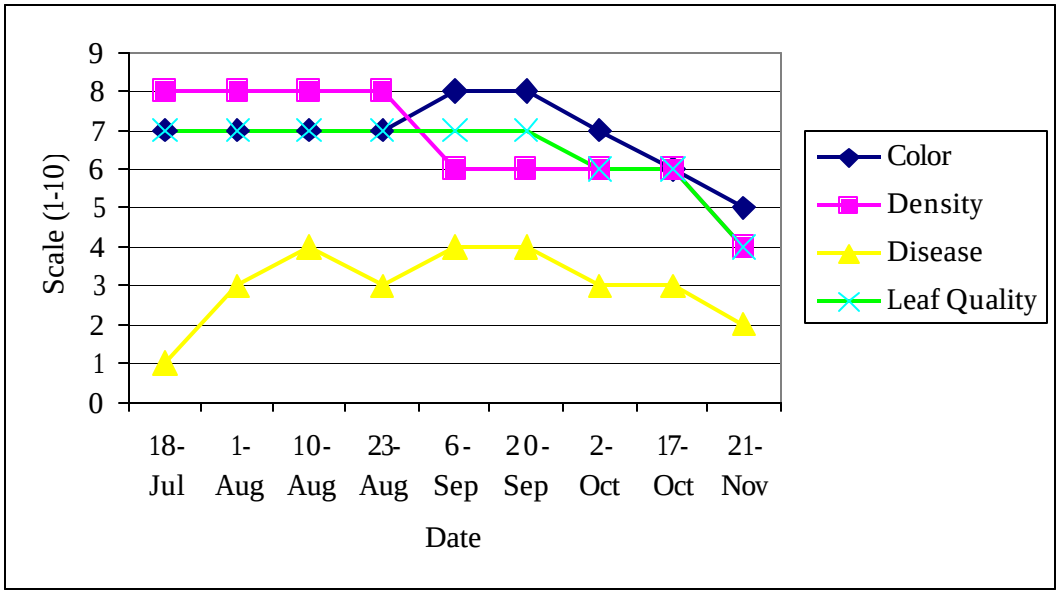
Table 12 Comparisons of Results between Greens 15 (tea) and 4 and 14 (Florative)

Description	Green 15 (Tea)	Green 4 (Floratine)	Green 14 (Floratine)	Target Areas
C.E.C.	5.6	6.9	5.3	5.0-10.0
pH	6.3	6.5	6.8	6.0-6.5
% organic matter	1.5	1.8	0.9	1.5-3.0
Ca:Mg Ratio	4.8	6.2	8.2	8:1
Calcium %	70	68.8	74.6	65-75
Magnesium %	15	18.4	15.2	10-15
Potassium %	3.4	5.1	6.8	4-8
Sodium %	2.0	2.1	1.3	1.5
Hydrogen %	14.4	5.6	2.0	0-5

Disease incidence was treated somewhat differently on the greens receiving compost tea and those receiving Floratine products. Green 4 received the following chemical treatments: Fore on 1st September, Bayleton on 7th October, and PCNB on 24th October. Green 14 was treated with Fore and Heritage on 1st September, Bayleton on 13th October and PCNB on 24th October. Green 15 received its first treatment on 13th October when Bayleton was applied. PCNB was applied to only the front half of the green on 16th November.

Figure 8 depicts the results of the monitoring that occurred on Green 15 throughout the duration of the study. These results track color, density, leaf quality and disease. The monitoring was done on a one to nine scale. For leaf quality, color and density the scale has the following interpretation: 1=poor, 5=average and 9=excellent. For the disease monitoring 1= none, 5=moderate and 9=heavy. The chart below indicates moderate to good density, good color and light to moderate disease on the green during the test period.

Figure 8. Green 15 Monitoring



Green 15 offers even fewer opportunities to draw conclusions about the effectiveness of the compost tea treatments. The green did not experience an increase in organic matter nor did we see an increase in the estimated amount of organic nitrogen release. For much of the season, the green performed very well with good to excellent scores for color density and leaf quality until the end of the season and the application of fungicide. Monitoring results show light disease, moving toward moderate on some sections of Green 15. Some observations for green 15 include:

- A possible increase of microbial activity may have occurred in the soils. The assumption is based on the significant fading that occurred on the green once fungicide was applied. Fading could occur as a result of a die off of microorganisms in the soil, leading to decreased turf quality as a result of the disappearance of the beneficial microbes. Fading and decreased turf quality was observed after the application of Bayleton, giving rise to the theory of a die-off of

soil life. However there is one caveat. Course staff indicated that some fading had occurred prior to the fungicide application. The extent of the earlier fading is not documented nor were there soil microbial tests available to chart any significant changes.

- Even though Green 15 showed incidences of disease it avoided any serious disease incidence until later in the season. Staff decided to forego treatment in order to specifically to observe this resilience and determine if the tea would effectively suppress disease. Because of the nature of the study Jackson staff was less likely to respond to a disease outbreak immediately, but waited until they felt that the disease threatened the turf and the greens to a point where delay could have serious consequences. The decision to forego treatment until necessary did not affect the playability of the green but did affect to some extent the visual quality (small disease patches were present). Color and density remained good. Consequently the green received fewer fungicide treatments than other greens on the course.

- Throughout most of the study period Green 15 maintained it color, density and playability. The Green did succumb to disease as did every other green on the golf course including serious outbreaks on the control greens located on the short-nine course. The compost tea did not prevent disease and there can be no definitive statement on its disease suppression capability. However, the application of compost tea to this green did not lead to deterioration or to significant turf quality problems and disease problems were relatively benign compared to other greens on the Course. Further testing of the disease suppression capabilities of compost tea is warranted on this green next year.

- In managing Green 15, Jackson staff adopted a curative rather than preventative approach to disease control. This meant treatment only with the appearance of a threatening disease rather than using chemicals as a disease preventative. The curative approach offers an opportunity to maintain turf quality while using chemicals only when necessary.

Small Putting Green

For this study the Jackson Park staff agreed to divide its large practice putting green into two sections. The largest two-thirds on the western side received a Floratine treatment while the remainder was treated with compost tea. Jackson staff established a turf collar between the two sections to differentiate between them.

The small putting green covers an area of 15,000 square feet and protocol established an application of 150 gallons of tea per treatment. This target was reached in most cases after calibration problems during the first application were resolved.

Of the three test greens the small putting green showed the worst response during the initial study period. Soon after compost tea applications began, turf quality deteriorated and disease broke out over most of the green. Turf yellowed and died and bald patches showed up on sections of the green. The small putting green is located in a very visible area and its deterioration led many to call into question the advisability of continuing with the test, especially since the larger putting green did not demonstrate similar problems. However since the use of the small putting green was not urgent, it was decided to continue with the field trials on the green, but take it out of play to eliminate additional stress.

The problems that occurred on the small putting green are hard to understand when reviewing the tissue and soil samples. Figures 8 through 9 below show generally good nutrient balance as well as sufficient soil nutrients to sustain growth. In spite of these results the small putting green showed deterioration during July and August.

The problems encountered on the small putting green led to three decisions:

1. The small putting green was taken out of play and was utilized exclusively to experiment with compost tea and it would be brought back into play once it could brought into balance with disease under control and turf demonstrating high quality;
2. Greater management of the small putting green including more frequent applications of compost tea and nutrients (beyond what was called for in the protocol); and
3. Agreement to top dress with a sand/compost mixture (30% compost:70% sand) to add organic matter to the soil to observe its effect on green health as well as its effects on moisture retention in the soil.

As a result of the decisions, the quality of the small putting green began to improve markedly in September. Turf quality improved and the incidence disease decreased sharply. Results were positive for the remainder of the year. If quality continues to be good, continued treatments and monitoring over a second season will provide useful findings, especially if quality can be maintained with the opening of the green for use.

Table 13 outlines the applications undertaken and the observations made on the small putting green.

Results for the Small Putting Green

The small putting green experienced more problems than the other greens. It experienced severe disease outbreak, loss of turf density, diminished turf color and yellowing. Despite adequate nutrient levels in both the soil and tissue, green quality declined early and required a significant time period to rebound. Table 14 shows the soil chemical results, which indicate that nutrient levels were generally well within target level and sufficient to maintain adequate quality. PH levels declined slightly from 6.3 to 6.0 and like Greens 1 and 15, nitrogen decreased from 9.0 ppm in the base analysis to 0.0 ppm on August 24th, rebounding to 10 ppm on September 25th but generally remained within desired ranges, while turf quality deteriorated.

Table 13. Field Application Log for Small Putting Green

Date of Application	Amount Compost Tea Applied	Interventions	Observations on Turf Quality
July 6th	83 gallons	None	Very good color and density good to excellent with no disease
July 20th	150 gallons	None	Sign of serious yellowing on the green.
August 3rd	150 gallons	Alfalfa meal applied at rate of 15 lbs per 1,000 sq. ft (0.15 N per 1,000)	East half of green has large yellow patches. Jackson staff attributed part the problem to heat stress and short mowing.
August 11th	150 gallons	Granular fertilizer to deliver 0.25 lbs of N per 1,000	Fusarium, yellow patch and anthracnose on the green. Both color and density are poor.
August 22nd	150 gallons	None	Color and density still poor, some polka-dotting from the fertilizer application. Disease seems to be increasing leading to thinning.
September 1st	150 gallons	Turf Tech Bio microbes (0.25 lbs) added to the tea to provide rhizobacteria to fight disease. Vitol (8-16-4) applied to obtain 0.25 lbs of N per 1,000 square feet	Disease still prevalent. Green still does not have good appearance.
September 7th (supplemental application)	Compost tea drench using 30 gallons of tea	None	Color fair but blotchy yellow and disease still active.
September 12th	150 gallons	Green was aerated, seeded and top-dressed. Turf-Tech Bio added.	With aerification conditions on the green difficult to determine.
September 21st	150 gallons	Turf Tech Bio added to mixture	Improvement in green color and density but still some splotchy yellow patches. Active fusarium but some patches filling in.
October 15th	150 gallons	None	Some minor mottling but more consistent. Color improved to good range and density improved. Little disease on green; vast improvement.
October 24th	150` gallons	None	Color and density improving. Some disease but light to moderate.
November 3rd	150 gallons	None.	Improved color, density and little disease evident
November 8th	120 gallons at a 4:1 dilution	Green aerified and top dressed with 30% sand/compost mix. Compost component was 30%.	Color and density good, little to no disease
December 1st	120 gallons at 4:1 dilution	None	Color and density good, little to no disease

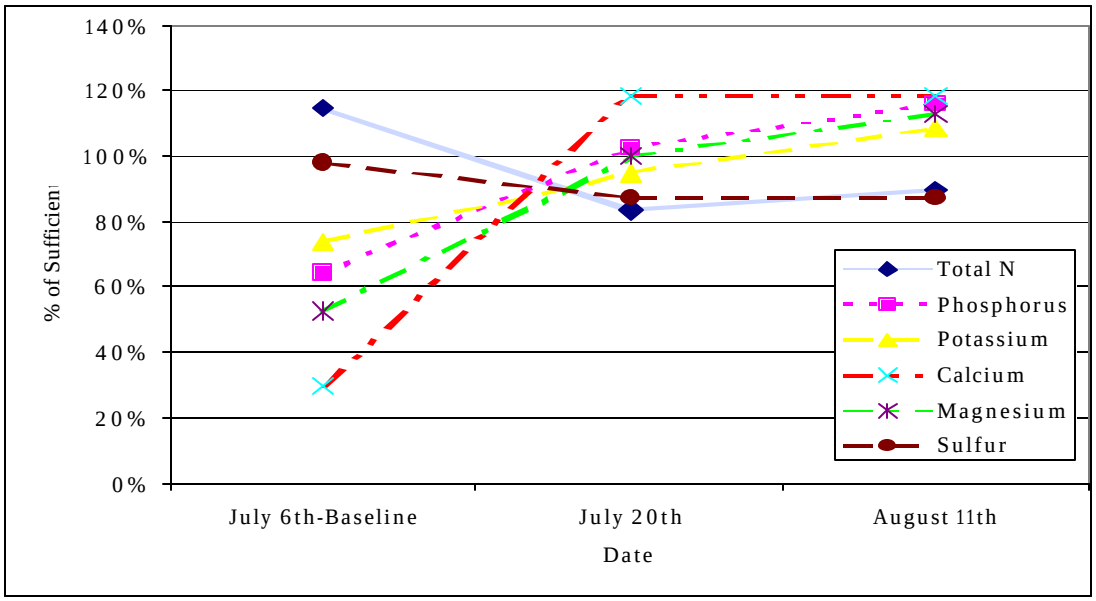
Table 14 Soil Chemical Test Results for the Small Putting Green

Test	Average Target Level	Baseline	August 24th	September 25th
C.E.C (Meq/100)	10	6.1	7.7	8.1
pH	6.5-7.0	6.3	6.0	6.0
% Organic matter	0.8	1.2	2.0	1.6
Estimated organic N release (lbs/acre)	N/A	44.0	60.0	52.0
Nitrogen (ppm NO3)	5.0	9.0	0.0	10.0
Phosphorus (ppm)	50	59	65	49
Potassium (ppm)	168	101	130	101

As in the case of Green 1, the percentage of organic matter increased from 1.2% in the baseline to 2.0% before falling in September to 1.6%. Estimated organic N release increased from 44.0 to 60.0 pounds per acre before declining after aerification to 1.6 lbs/acre. These results might lead to the conclusion that the green would achieve some level of disease suppression potential and exhibit good color. This did not occur. Staff at Jackson attributed part of the decline to heat stress and low grass length from mowing. Mowing scars on elevated patches were noticeable during the test period. However, other greens on the Course experienced similar mowing and management regimes and did not exhibit the level of deterioration that the small putting green exhibited during the first two month of the field trial.

Tissue sample results in Figure 9 indicate more variability in nutrient tissue levels than the other test greens. As in the other samples, the tissues contain much higher levels of calcium than under baseline conditions. However decreases in nitrogen are observed over the sampling period although results remain within 80% and 90% of sufficient. As with the tissue samples for Greens 1 and 15, the variability around the 100% sufficient level is less than for the baseline samples.

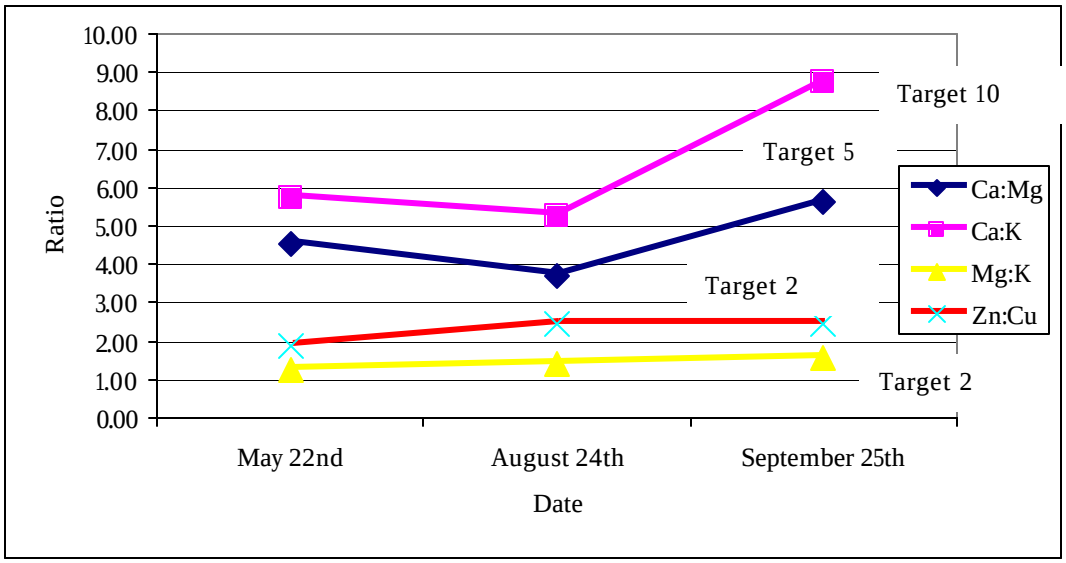
Figure 9. Tissue Sample Test Results for the Small Putting Green



Soil nutrient ratios in Figure 10 also indicate slightly greater variability than the results obtained from the other two test greens. Similar to the two previous compost tea treated greens, the ratios tend to be closer to established targets after the applications of compost tea as compared to the baseline. Calcium ratios were generally low at the baseline and throughout the first two months of tea applications. These results may help explain the poor response observed on the small putting green during the first two months of the trial. The September 25th test yields results closer to desired ranges. These results correspond to improved turf quality and disease suppression on the small putting green as can be noted from monitoring results in Figure 17. Compost tea applications, along with additional inputs apparently led to improvement in soil nutrient ratios and concomitant improvements in turf quality.

The small putting green, like Greens 1 and 15 demonstrated a high FE:MN ratio results. The results are not included in the chart for reasons of scale (target 1:1; baseline45:1, test results 28 and 25:1 respectively).

Figure 10. Soil Nutrient Ratios of Small Green compared to Established Targets



Comparisons with Floratine Sites.

During the trials the large putting, covering approximately two-thirds of the practice putting area received an application of Floratine products, while the small putting green received compost tea applications as described above. The results of the soil tests conducted on these greens provide the most striking comparison of soil response to the two products. Originally the larger section of the practice putting green was identified as a control for the small putting green. However the course decided to test Floratine on this practice green and relegated to holes on the short-nine as control greens. Despite this change it is useful to compare the results from the two greens, especially given that they were connected prior to the establishment of the collar that separated them for purposes of this field trial.

Chemical soil test results for the large putting green are derived from soil collected in early November, while the small putting green samples were taken in late September. Both greens had received respective treatments for three months or more. Table 15 shows the results and demonstrates close similarities between the chemical composition of the soil in the two greens. This is not surprising given that the two putting greens were linked and were divided only for purposes of this study.

What is surprising is the level of disease that affected the small putting green. The large putting green did not suffer the severity of problems that the small putting green suffered. The large putting green also maintained good turf quality for much of the season.

The large putting green was attacked by disease, but the incidence of disease was much lower and occurred much later in the year. The large putting green received herbicide treatments on September 1st, October 13th and October 24th. These applications were effective in suppressing the disease on the green. The large putting green maintained a healthy appearance for the duration of the study period. The small putting green began an early deterioration that was not anticipated given the relatively good balance of nutrients.

Jackson staff decided early in the field trials not to treat the small putting green with herbicides, agreeing to allow additional compost tea and fertilization applications in an attempt to restore the health of that green. To a certain extent that approach succeeded. By September, the small putting green appeared greener; had denser turf and suffered from much less disease than in the summer.

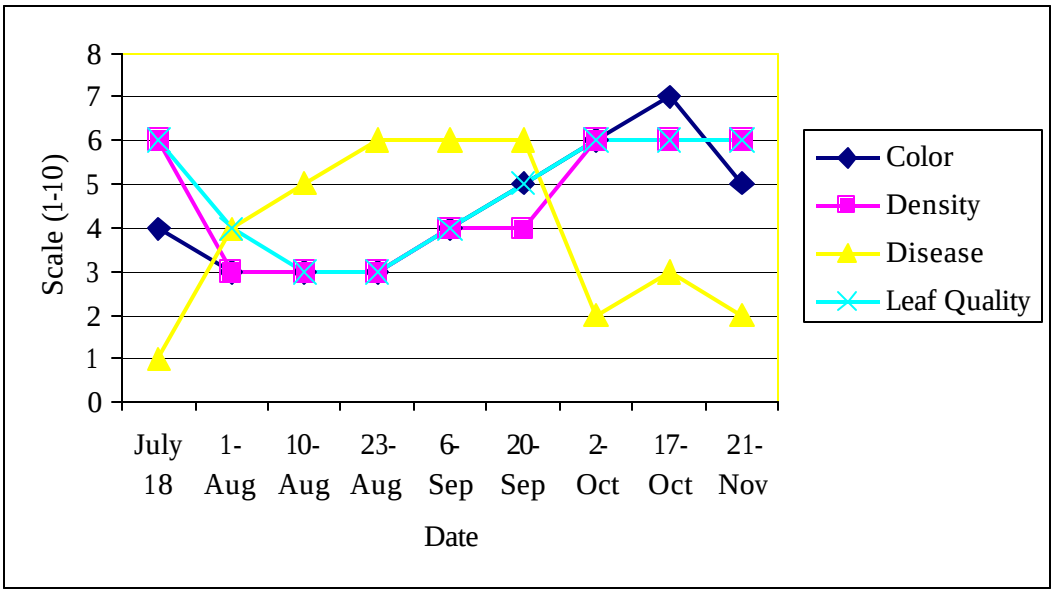
The caveat is that success came under less than normal operating conditions. Staff mowed the green less often and they closed the green to play during the recuperation period, while the large putting green remained in play throughout the year and received regular mowing.

Table 15 Comparisons of Results between Large and Small Putting Green

Description	Small Putting Green (Tea)	Large Putting Green (Floratine)	Target Ranges
C.E.C.	8.1	5.4	5.0-10.0
pH	6.0	6.1	6.0-6.5
% organic matter	1.6	1.5	1.5-3.0
Ca:Mg Ratio	5.64	4.8	8:1
Calcium %	54.7	55.6	65-75
Magnesium %	16.2	19.5	10-15
Potassium %	3.2	6.0	4-8
Sodium %	1.8	1.5	1.5
Hydrogen %	19.8	17.5	0-5

Figure 11 depicts the results of the monitoring that occurred on the small putting green throughout the life of the study. These results track color, density, leaf quality and disease. The monitoring was done on a one to nine scale. For leaf quality, color and density the scale has the following interpretation: 1=poor, 5=average and 9=excellent. For the disease monitoring 1= none, 5=moderate and 9 =heavy. The chart below indicates a very quick spike in disease and deterioration in color., leaf quality and density soon after application of compost tea began. At the end of September these indices begin to move significantly to the more positive side of the scale with light disease, improved color, density and leaf quality. This occurred after more intensive management, including fertilization and additional tea applications, and closing off of the green to public play.

Figure 17. Small Putting Green Monitoring



Conclusions for the small putting green are difficult to draw. Compost tea did not fight disease nor did it maintain turf quality on the small putting green during the first two months. In that respect the trials failed on this green. Heat stress on the green was high and some turf scalping occurred on elevated patches of the green when mowing. Also baseline soil chemical ratios were low for some nutrients, especially calcium. If the study had responded immediately (within the first 30 days) with additional nutrients to bring the soil into better balance along with application of compost tea, the extent of the turf problems might have been ameliorated. However this approach would have comprised the regime established in the protocol.

Once it was determined that compost tea alone was not working on the small putting green, a decision was made to abandon the protocol and respond more actively to conditions on the green to improve its quality. This approach achieved positive results.

Jackson Golf Course agreed to put aside the small putting green for testing purposes. The Course applied no fungicide to fight the disease and agreed to test the response of the green to top-dressing using the 30% compost. The mowing regime was modified to cut a higher length and play on the green was suspended. The combined effects of these treatments and actions will only be known next year, when the effects of increased organic matter, greater microbial soil balance and compost tea applications can be assessed. Late-year improvements in the appearance and overall

turf quality on the small putting green represent a positive sign. Improvements in turf quality corresponded to improvements in soil nutrient ratios indicating that compost tea was apparently having a positive effect on soil nutrients.

If quality can be maintained with the tea applications throughout the early Spring of 2001, the small putting green should be re-opened to play and continue to receive compost tea treatments and compost top-dressing. Monitoring should continue throughout the life of these interventions. Recommended actions for this green include:

- Continued top-dressing with compost/sand mixture;
- Continuation of regular compost tea applications;
- Use of organic fertilizers;
- Disease treatment with targeted and least-toxic fungicides if and when required.

14th Fairway

Application of compost tea occurred on the 14th fairway on a section sloping down to a water retention pond. Algae covered the pond and the Course wanted to limit nutrient loading from fertilization. When the application began grass on the pond bank was weak and stunted and the bank was covered with bare spots. During the course of this study no fertilizer was applied to this area.

The fairway area covered 7,500 square feet and generally received between 50 and 75 gallons of tea. Vitol was added to the mixture as a soil treatment to loosen compacted soil. Applications continued through October.

The turf response varied by the time of year. Turf began to respond and some improvement in turf growth was noticed after the first month of the applications. In addition use of a soil probe indicated a decrease in soil compaction. However turf response was hindered by drought. The area receiving compost tea treatments lay outside reach of the Course irrigation system. During the hottest and driest months, the test part of the fairway received no supplemental irrigation. The lack of water caused stress in the turf and never allowed it to recuperate fully.

Once the rain began in the fall the turf regained its color and began growing in again. This process of improvement in turf condition should continue with some wetter weather especially with the observed improvement in soil conditions (less compaction) in the application area.

The test on the fairway was done to determine the effects of tea use on the soil and turf, but this test was deemed less important than the greens' applications in terms of chemical-use reduction. Consequently only visual monitoring during application times was undertaken. No external monitoring occurred nor were soil chemical tests taken. Soil conditions were access visually and by use of a soil probe.

Conclusions and Recommendations for Golf Course Tea Trials

The results of these field trials were inconclusive. The effectiveness of compost effectiveness of compost tea in reducing disease incidence in golf greens while maintaining desired color and density was not determined. The study period was too short and results from multiple growing seasons are necessary to make any real determinations.

The study originally set out to test whether compost tea applied on a regular basis would be sufficient for greens' management. The first year's experience with tea at Jackson Park Golf would indicate that the answer is no. The application of compost tea every two weeks proved insufficient. Some improvement was observed with an application every ten days. The question arises whether improvements might be seen with weekly applications. Weekly applications may make some technical sense but they would not make sense economically, especially at a Course like Jackson Park, which does not have a modern irrigation system.

In some cases the tea-green performed well. For example, Green 1 suffered limited disease problems and required its first fungicide application in October. Turf thinning occurred, but such thinning is a normal occurrence on that green, according to staff. Green 15 showed good color and density for most of the season while the small putting green suffered from early disease and loss of color and density. In no case did the effects of compost tea lead to the destruction of any green, but poor response on the small putting green led to that green closing to public use. Tests indicate some improved nutrient balance in the soils and staff noticed possible effectiveness against disease. However, results are preliminary and more information is needed.

The following represent findings and recommendations from the study:

Objective: Determine the effectiveness of compost tea in decreasing disease incidence and maintaining turf quality on golf greens under normal play conditions in an effort to reduce the use of pesticides.

> Finding 1. The study period was too short to draw specific conclusions on compost tea's effectiveness.
>
> Finding 2: Although the results were inconclusive, compost tea greens received fewer applications of fungicide than the control greens three and nine located on the short-nine course.

- Recommendation: The City of Seattle should continue to test the effectiveness of compost tea at the golf course taking into account the need for information over a longer time period. The period of time employed to test compost tea effectiveness was too short. The study needs be carried out over several complete seasons to obtain useful information. In developing future application programs the City should keep in mind the following:

    a) Commence earlier in the year to begin building up soil life and obtaining the desired soil chemistry balance;

b) Undertake soil tests at least every eight weeks to observe changes in soil chemistry and nutrient balance;

c) Use different sources of high quality compost (compost with abundant and active microbial life) and mix them before brewing to obtain greater diversity of microbiological life;

d) Attempt to achieve a desired soil chemistry balance with the addition of required nutrients and test the effectiveness of compost tea on chemically balanced soils. Compost tea may be more effective in suppressing disease and maintaining turf quality on soils in balance and testing for this would be beneficial.

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- Recommendation: Continue using the small putting green as an experimental site to apply compost tea regularly and to test the effectiveness of organics in maintaining soil fertility and suppressing disease.

    a) Continue to aerify the small putting green on a regular basis and top dress it with the mixture of sand and compost at a mixture not to exceed 30% compost.

    b) Find a least toxic source of fungicide (e.g. hydrogen dioxide) and test its effectiveness in treating disease. Apply as a curative on "as needed" basis to the small putting green. Where this is not effective use a targeted fungicide on an as needed basis only.

    c) Fertilize as needed to obtain the required soil balance and provide nutrient requirements. Source greens' quality organic material for the fertilizer applications.

    d) Continue to monitor the results and responses across the seasons. This monitoring should include an assessment of moisture retention in the green and any issues arising from added water holding capacity in the greens as a result of the addition of compost in the top-dressing.

    e) Once confident that the green is responding appropriately, 0pen up the green again for public use to observe its response to normal playing conditions.

Finding 3: The application of compost tea is a labor-intensive effort (as carried out at Jackson Park where a modern irrigation system does not exist) and labor requirements may outstrip the ability to maintain an effective program.

- Recommendation: The City should continue to manage applications at the small putting green until Jackson can manage the applications.

- Recommendation: Greens 1 and 15 should also continue to receive compost tea applications. These applications will provide the City with useful longer-term information. However to limit the labor burden and increase cost-effectiveness we suggest a combined application of compost tea and Floratine products. Compost tea can be mixed with the Floratine products and can be applied at the same time with the only additional labor requirement arising from

the tea brewing the previous day. The Floratine regime will ensure provision of nutrients and other benefits to the plants while the compost tea will supplement the beneficial microbe populations in the soil and provide a potential disease suppression boost.

This recommendation is based on the fact that the application of Floratine products at Jackson Park provided the greens with nutrients and other essential materials that maintained the greens to the standards desired by golf managers. However, Floratine greens did suffer disease problems. Several Floratine products contain beneficial microbes however they are in a dormant state and lack the vast diversity found in compost teas.

There is some indication that compost tea may have disease suppression potential. Mixing the compost tea with the Floratine will ensure delivery of product with good nutrient balance along with the disease suppression potential offered by a large diversity of active soil microbes. This approach will provide a field demonstration opportunity to observe the results of two very promising products working together. It will also permit the testing of compost tea effectiveness under conditions of desired soil nutrient balance.

Finding 4: Jackson Park management of disease on the compost tea greens followed a curative rather than preventative approach. Staff treated disease only when they considered the disease seriously threatened the turf. This approach reduced overall chemical use on the course.

In the past, the Course followed an established maintenance program that involved fertilizer and fungicide applications to prevent disease and then further fungicide applications when necessary to treat disease.

- Recommendation: The Course should give consideration to adopting a curative rather than preventative approach to disease treatment over the entire coarse to determine the achievable level of chemical reduction. As part of this approach the Jackson should give consideration to:

  a) Testing the effectiveness of least-toxic fungicides (e.g. Zerotol, 27% hydrogen di-oxide) and/or the use of chemicals that might limit the die-off of beneficial micro-organisms in the soil;

  b) Monitoring disease and mowing regimes to prevent the possibility of spreading disease through maintenance practices;

  c) Balancing nutrient levels especially Nitrogen to levels recommended for disease suppression; and

  d) Raising mowing heights slightly to reduce turf stress.

4. Pritchard Beach; Experiments with Compost Tea and Mycorrhizae Applications on Wet Meadow and Upland Native Plant Communities

Introduction

Pritchard Beach Park is a unique site to test the effectiveness of compost tea. The Seattle's Department of Parks and Recreation has been working in Pritchard Beach to restore a wetland and to stimulate the growth of native vegetation on the poor soils remaining from previous site use. The site has 3.5 acres of wetland and 1.5 acres of upland native woodland that have recently been planted with native plants. A protocol was developed to test the effectiveness of compost tea in the wetland and upland areas in addition to a turf area close to the swimming area and park offices.

Soil samples were collected for microbial analysis at the meadow and upland sites in mid-May prior to the initiation of tea applications. The microbiological tests indicated in the meadow had low numbers of protozoa, which suggesting that there are few microbes available to cycle nutrients in the soil. Microbiological test in the upland area indicated good active fungal biomass which is especially favorable for native tree growth although further soil tests indicated the need for increased mycorrhizal fungi presence. These fungi can help increase plant's resistance to root rot and other diseases.

The City staff was responsible for the application of the tea. Starflower Foundation staff undertook the monitoring of the site and three monitoring administrators from Starflower , Acacia Smith, Leslie Phillips-Catton, Jennifer Symms, carried out the monitoring and prepared this following report.

Methodology

Site Selection

The compost tea trials involved experimentation with compost tea and mycorrhizal fungi, both separately and combined. Trial sites were set up in two different areas in the park; four plots in the upland area and four plots in the wetland area. Each area has differing ecologies and plant communities: Upland plots are dominated by native shrubs (see detailed species list in charts below) and the wet meadow plots are dominated by natives such as lupine species, red fescue, toad rush, meadow barley and a few non-natives.

The four plots were established in each area in order to experiment with the following application combinations:

- Compost tea only
- Mycorrhizae only
- Compost tea and mycorrhizae
- No treatment/control plot.

Brewing Compost tea

Compost tea was brewed every two weeks beginning in May, 2000. A 12-gallon Growing Solutions tea brewer was used. De-chlorinated water (using a Custom Pure Activated Charcoal filter) was used for all tea brews. The tea was brewed with the following proportion of ingredients:

12 gallons de-chlorinated tap water
7 pounds fresh compost (for information on source, see below)
16 oz crystallized molasses
2 oz. soluble Atlantic kelp

Compost, molasses and kelp were added to 12 gallons of de-chlorinated tap water and the brewer ran for 18-20 hours. The resulting concentrate was diluted 1:10 with de-chlorinated tap water before applying to soil and foliage. Compost tea was applied at the rate of 2-3 gallons of diluted tea per 1000 square feet. All treatments continued through early October 2000. Monitoring of these plots began in late June 2000, ending in mid-September 2000.

Compost source

There were three sources of compost for the Prichard Beach study, Columbia River Gorge Organic Fruit Company, Seattle's Interbay P-Patch, and Ground Up. The compost from these sources was used both individually and blended.

Mycorrhizae Source

Five species of ectomycorrhizae and seven species of endomycorrhizae were used to annoculate the soils in the test plots. The source of the mycorrhizae spores was Mycorrhisae Applications, Inc., sold in tablet form. The rate of application was one tablet per 1 foot of plant height.

Soil Testing

Initial soil samples were taken for a number of these areas in order to assess the initial health of the soil and soil food web. That data is not presented in this summary. Site monitoring data and soil data were collected throughout the study period to assess how the three treatments affect plant species in each site. These data include percent cover across all plots in and growth measurements of specific shrubs in an upland environment.

Wetland Compost Tea and Mycorrhizae Test Plots

This area was seeded in the fall/winter of 1999 but germination of many species was poor. There are also low lying sites (indentations) in the landscape which remain saturated longer than other areas and actually pool water in the winter months. This prolonged saturation may have caused decreased seed germination resulting in bare patches throughout the meadow. Table 16 provides additional brief descriptions of the wetland plots site characteristics.

Table 16. Site Characteristics of plots in wetland area of Prichard Beach

Site	Description
Soil Moisture	Saturated from November to June; mostly dry July and October
Exposure	Full sun
General Vegetation Cover	Toad Rush (Juncus bufonius) Red Fescue (Festuca rubra Large-Leaved Lupine (Lupinus polyphyllus) other native Lupinus sp., Meadow Barley (Hordeum brachyantherum Regreen
Other features	Jute fabric for erosion control

Four plots were established in the wet meadow site (for specific plot layout, see map attached). The treatment regimes for each of the individual wet meadow plots included compost tea only, mycorrhizae only, and compost tea/mycorrhizae mixture. Table 17 lists details of the treatments and monitoring for the wetland plots.

Table 17. Schedule of Treatment and Monitoring of Wetland Plots.

Plot #	Treatment	Treatment Dates	Monitoring Dates
1	Tea Only	May 18 June 2 June 15 June 29 July 12 July 26 August 10 August 24 September 6	June 26 July 29 August 18 September 19
2	Mycorrhizae only	July 12	June 26 July 29 August 18 September 19
3	Tea and mycorrhizae	May 18 June 2 June 15 June 29 July 12 July 26 August 10 August 24 September 6	June 26 July 29 August 18 September 19
4 (Control Plot)	Control (no treatment)	No Treatments	June 26 July 29 August 18 September 19

Monitoring and data collection included identifying species present in each plot and visually estimating the percent cover per species (which is represented by a cover class value indicating a percentage range for cover). It is difficult to measure a specific percentage cover for a species therefore using the range

method was chosen as a more efficient method than attempting to pinpoint an exact percentage. Cover class values are as follows:

0 = no presence
T = Trace (less than 2% cover of species for entire plot)
1 = 2-5% cover of species for entire plot
2 = 6-15% cover of species for entire plot
3 = 16-25% cover of species for entire plot
4 = 26-50% cover of species for entire plot
5 = 51-75% cover of species for entire plot
6 = 76-95% cover of species for entire plot
7 = 96-100% cover of species for entire plot

Results of Wetland Treatments.

There is no predictable trend evident from this wetland compost tea study data. The slow disappearance of many grasses and forbs (such as Juncus bufonius, Lolium perenne, and Lotus purshiana) is likely due to normal end of season senescence. Table 18 indicates the change in percent cover of species during the study period.

Table 18. Cover Class Values for Wet Meadow Study Plots. Each species has four values per plot representing the four different monitoring dates: June 26, July 29, August 18 and September 19

Vegetation Species * = Native	Plot #1 Compost Tea Only	Plot #2 Mycorrhizae Only	Plot #3 Tea + Mycorrhizae	Plot #4 Control
Achillea millefolium *	2 - 1 - 1 - 0	T - T - T - 0	T - 1 - 1 - 1	T - 1 - 1 - 1
Agrostis sp.	0 - 0 - 0 - T	0 - 0 - 0 - T	0 - 0 - 0 - T	0 - 0 -T - T
Anaphalis margaritacea	0 - 0 - 0 - 0	0 - 0 - 0 - 0	0 - 0 - 0 - T	0 - 0 - 0 - 0
Bromus sp.	1 - T - T- T	1 - T - T- 0	1 - T - T - 0	1 - T - T - T
Epilobium sp. *	0 - 0 - 0 - 0	0 - 0 - 0 - 0	0 - 0 - 0 - 0	0 - 0 - 0 - T
Festuca rubra *	3 - 3 - 3 - 3	3 - 3 - 3 - 3	2 - 2 - 4 - 4	3 - 2 - 3 - 4
Gnaphalium uliginosum	0 - T - T - T	0 - 0 - 0 - 0	0 - T - 1 - 1	0 - 0 - 0 - 1
Holcus lanatus	T - T - T - T	T - T- T- 0	0 - 0 - 0 - T	T - T- T - T
Hordeum	3 - 2 - 2 - 1	2 - 2 - 1 - 2	3 - 3 - 1 - 2	2 - 2 - 2 - 2
Hypochaeris radicata	T - T - T - T	0 - 0 - 0 - 0	0 - 0 - T - 0	0 - 0 - T - 0
Juncus bufonius *	4 - 3 - 3 - 2	3 - 3 - 3 - 3	4 - 4 - 5 - 4	3 - 3 - 3 - 4
Lolium perenne	1 - T - T - T	1 - 1 - 1 - 0	T - T- T - T	1 - 1 - T - T
Lotus purshiana *	1 - 1 - 1 -T	1 - 1 - 1 - T	1 - 2 - 1 - T	T - 1 - T - 1
Lupine polyphyllus *	0 - 0 - 1 - 1	0 - 0 - 2 - 2	0 - 0 - 2 - 2	0 - 0 - 1 - 2
Lupine sp. *	1 - 2 - 2 - 3	1 - 2 - 2 - 3	1 - 2 - 1 - 2	T - 2 - 1 - 2
Medicago lupulina	1 - T - T- 0	1 - 1 - T - 0	1 - T - T - 0	T - T - T - 0
Plantago lanceolata	T - T - T - T	0 - 0 - 0 - 0	0 - T - T - 1	0 - 0 - 0 - T
Poa annua	1 - T - T - 0	2 - T - T - 0	2 - 1 - T - 0	2 - 2 - T - 0
Ranunculus repens	0 - 0 - 0 - 0	0 - 0 - 0 - 0	0 - 0 - T - T	T - T - 0 - 0
ReGreen	2 - 1 - 1 - 1	2 - 2 - 2 - 1	2 - 1 - 1 - 1	2 - 1 - 1- 1
Trifolium repens	1 - 1 - 1 - 1	T - 1 - 1 - 1	T - 2 - 2 - 3	T - 1 - 1 - 2
Bare Ground	3 - 3 - 2 - 2	2 - 2 - 2 - 2	1 - 1 - T - 1	2 - 2 - T - 1

Does Mycorrhizae affect growth of vegetation? The only species that reacted to mycorrhizae across the 4 plots is meadow barley (Hordeum brachyantherum), which senesced as usual in plot 1 (tea only), but made a comeback with new germination and growth by the September 19th survey in plots 2 and 3 (mycorrhizae and tea + mycorrhizae only respectively). The control plot, however, shows a constant percent cover of meadow barley over time, suggesting that its senescence rate equals its germination rate. Since the control plot exhibits a 1:1 ratio of germination to senescence, the differing rates between plots are likely attributed to differences in individual plot conditions (such as elevation and moisture), rather that to influence by mycorrhizae. This does not, however, prove that mycorrhizae are not beneficial to plant growth. The lack of conclusive results may be due to an insufficient duration of the treatment, poor soil quality, or the inability of mycorrhizae to efficiently adapt to this type of soil (mainly clay).

Does Compost Tea affect growth of vegetation?
There is no conclusive result as to whether compost tea positively or negatively affected vegetation growth overall. Some species percent cover decreased over time, and some increased over time, irregardless of treatment. This suggests that either the length of the experiment was not sufficient to produce visible results, or compost tea is ineffective in this environment. Extending the length of compost tea treatments in this area would allow the tea to accumulate and amend the soil to some degree.

Recommendations for future studies in Prichard Beach wetland area:

1. Collect baseline data before mycorrhizae treatments begin.
2. Rule out variables such as poor soil quality by testing mycorrhizal levels in the soil to determine their success in this habitat. Test and compare soils in control plots and compost tea-treated plots to detect possible beneficial changes in soil microbiology.
3. Correlate experimental treatment dates closely with monitoring dates.

SE Upland Compost Tea and Mycorrhizae Test Plots

Certain species have not done well in these plots overall, such as Salal, possibly due to sun exposure, poor soil quality or a lack of moisture. Douglas Fir has also suffered throughout these plots with about 50% mortality. These stressed conditions were observed prior to treatments, however, and are not necessarily correlated to the experiments.

Table 19. Site Characteristics of plots in upland area of Prichard Beach

Site	Description
Soil Moisture	Dry upland soils. Quality varies from fair with some clay content to extremely compacted
Exposure	Full sun; some shade to understory
General Vegetation	Native species including Thimbleberry (Rubus parviflorus) Tall Oregon Grape (Mahonia aquiflolium) Salal (Gaultheria shallon) Sword Fern (Polystichum munitum) Douglas Fir (Pseudotsuga menziesii) Big Leaf Maple (Acer macrophyllum). Non-native species including Clovers (Trifolium sp.) Bentgrass (Agrostis sp.)
Other Site Features	4-8" of mulch present; irrigation for trees and large shrubs (watered approximately once every 30 days for 24 hours each session)

Four plots were established in the upland sit). The treatment regimes for each of the individual plots included compost tea only, mycorrhizae only, and compost tea/mycorrhizae mixture. Table 20 lists details of the treatments and monitoring for the wetland plots.

Table 20. Schedule of Treatment and Monitoring of Upland Plots.

Plot #	Treatment	Treatment Dates	Monitoring Dates
1	Mycorrhizae only	July 12	June 26 July 29 August 18 September 19
2 (Control Plot)	Control (no treatment)	No Treatments	June 26 July 29 August 18 September 19
3	Compost tea and mycorrhizae	May 18 June 2 June 15 June 29 July 12 July 26 August 10 August 24 September 6	June 26 July 29 August 18 September 19
4	Compost tea	May 18 June 2 June 15 June 29 July 12 July 26 August 10 August 24	June 26 July 29 August 18 September 19

		September 6	

The monitoring/data collection for these plots involved identifying species present in each plot and visual estimating percent cover per species using a cover class values. Because it is difficult to measure percentage consistently, a range of cover classes was used. Cover class values are as follows:

0= not present
T= Trace; represents less than 2% cover of species for entire plot
1= 2-5% cover of species for entire plot
2= 6-15% cover of species for entire plot
3= 16-25% cover of species for entire plot
4= 26-50% cover of species for entire plot
5= 51-75% cover of species for entire plot
6= 76-95% cover of species for entire plot
7= 96-100% cover of species for entire plot

For the purpose of tracking height changes, three shrub and one tree species was selected for individual monitoring. Species that were selected occur in all four plots were thimbleberry, sword fern, Douglas fir and Oregon grape. The heights of three individual plants was measured and recorded each month in feet, and the average of the three 3 individuals (average change in height) was used to compare growth changes from the beginning of monitoring in June to the end in September.

Results of Upland Treatments.

While no definitive proof emerged from the study that compost tea is effective in improving the growth and health of plants in the upland areas, some interesting observations were recorded. These are provided below.

Does compost tea and/or mycorrhizae affect vegetation growth?

There is a dramatic increase in average height of both thimbleberry and Douglas fir in the plots treated with compost tea alone, with the compost tea/mycorrhizae combination, and with mycorrhizae only. Thimbleberry showed most growth in the tea only plot (#4) while Douglas fir had most success in the mycorrhizae only plot (#1).

In addition, the Oregon grape and swordfern exhibited most dramatic change in height in the control plot, suggesting that compost tea and or mycorrhizae addition do not affect the growth of these species, or have not as yet affected their growth.

The differences in growth observed between species cannot be explained by a preference of one treatment over another by plant type. Evergreen species exhibit differing results (Oregon grape and swordfern most successful in control plot; Douglas fir most successful in mycorrhizae plot). In addition the non-evergreen shrub thimbleberry was most success in the compost tea plot.

Both thimbleberry and Douglas fir showed increased growth rates in all experimental plots as compared to the control plot (#2), suggesting that compost tea, micorrhizae, and the compost tea/mycorrhizae combination are all beneficial to the growth of these two species. Because this result was not found in all species, the finding suggests that the response to compost tea and mycorrhizae varies by species and further studies on specific species-response would be helpful. Other reasons for variation in plant response could be the duration of study. Plant species that are generally slower growing such as conifers and some evergreens may require longer treatment periods to fully measure the effect of treatment over time. Site factors including variation in soil composition, moisture content and sun exposure could also influence the effectiveness of compost tea and mycorrhizae treatment by species.

Recommendations for future studies in Prichard Beach upland area:

1. Continue treatments in same plots in second year.
2. Continue to monitor same species of plants to obtain long-term effectiveness of treatment.
3. Monitor next year starting earlier in the spring, and correlate treatments with monitoring regime.
4. Compare the data set from this year, with that of next year, extrapolating longer-term results.