Microbial Content of Actively Aerated Compost Tea after Variations of Ingredients or Procedures

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Abstract

Compost tea describes a procedure where compost is mixed with water. The mixture may be left to stand with minimal disturbance (also called "compost extract" or "steepage") or actively supplied with oxygen by an aquarium pump to stimulate population growth of aerobic microbes. This project examined actively aerated compost tea. Over a three-year period, 25 experiments were conducted where a standard recipe was compared to variations of ingredients or procedures. Identification and count of microbial content was done by direct microscopy. The "standard recipe" was 15 L of tap water (pH 7.0), 485 g of composted yard waste, 285 g of commercial worm castings, 30 ml of humic extract, 30 ml of commercial kelp *Ascophyllus nodosum* and 30 ml of fish fertilizer. The procedure was to aerate water for 60 min in a commercial brewer, add ingredients which are removed after five hours, then maintain brewing for another 17 hours at room temperature of 20°C. Results indicate that longer brewing time increased protozoa activity; addition of humic acid stimulated fungi activity; addition of kelp stimulated protozoa activity; addition of fish fertiliser stimulated fungi activity and increased nutrient content; use of worm castings resulted in increased fungi content; and mixing protein food with compost ahead of brewing resulted in higher protozoa activity. However, replicated experiments were difficult as the microbial content changes continuously over time and it was not possible to accurately measure a large number of samples in a short period.

INTRODUCTION

Non-aerated compost tea requires procedures in which compost is mixed with water and left to stand for many days with minimal disturbance. It has been used for many years in agriculture and has also been called "extract", "slurry" or "steepage" (Quarles, 2001). A frequent procedure is to mix compost with water in a volume ratio of 1:5, place in an open container, stir once then allow to sit for 10 days (Elad and Shtienberg, 1994) or stir twice during a 7-day incubation period at 20 to 22°C (Al-Dahmani et al., 2003).

Non-aerated compost tea applied as foliar sprays can provide adequate control of plant diseases such as grape powdery mildew (Trankner, 1992). Consistent and significant suppression of grey mold (*Botrytis cinerea*) on geranium was obtained with tea made from composted chicken manure or composted yard waste, but adding nutrients did not help with disease suppression (Scheuerell and Mahaffee, 2006).

Non-aerated compost tea favours the extraction of antibiotic compounds that play an important role in suppression of plant pathogens (Cronin et al., 1996). Microorganisms may also be important, as heat treatment of finished tea eliminated disease suppression of grape powdery mildew, bean mould and tomato late blight (Scheuerell and Mahaffee, 2002).

Actively aerated compost tea is more recent. The mixture of compost and water is supplied with active aeration, for example, by an aquarium pump. The high oxygen concentration stimulates population growth of aerobic microbes which help with disease prevention, nutrient cycling and soil structure. By contrast, these beneficial microbes may not survive in non-aerobic compost tea because of anaerobic conditions (Ingham, 2005).

Actively aerated compost tea applied as a drench was effective to suppress damping-off (caused by *Pythium ultimum*) of cucumbers grown in soilless greenhouse media. Kelp and humic acids alone did not suppress damping-off, but triggered disease suppression when added to any of three different types of compost. Diluting the finished tea with water, or imposing heat treatment significantly reduced suppression, indicating that the impact was related to microbes but not nutrients (Scheuerell and Mahaffee, 2004).

This project examined actively aerated compost tea. It followed a field trial where weekly applications provided inconsistent control of powdery mildew of apple trees in commercial organic orchards (Lanthier and Peters, 2006).

MATERIALS AND METHODS

Over a three-year period, 25 experiments were conducted inside a laboratory in Kelowna, British Columbia (elevation 1,000 m). Actively aerated compost teas were prepared using the commercial brewers “Bobolator” (North Country Organics, Vermont, http://www.dirtworks.net/Images/BrwrManBitti-1.pdf) and “Keep It Simple, Inc.” (Redmond, Washington, http://www.simplici-tea.com/). Each brewer came equipped with an aquarium-type pump to supply the appropriate amount of oxygen into the container.

Each experiment was based on a “standard” compost tea. For the procedure, a five US gallon brewer was filled with 15 L of water (drinking water from City of Kelowna, British Columbia, pH 7.0, Electrical Conductivity 0.24, varying between 15 and 21°C); the water was actively aerated for one hour then filled with the required additives; the compost products were removed after 5 h and the tea actively brewed another 17 h. After each brewing, equipment was cleaned thoroughly with hydrogen peroxide.

The “standard” recipe was as follows: composted yard waste 485 g (product Glengrow, City of Kelowna landfill, British Columbia); vermicompost 485 g (Nurturing Nature Organics, Lake Country, British Columbia); humic acid 30 ml (Multi-dynamic Humic Extract, Tecologic Products Ltd., Calgary Alberta); kelp 30 ml (Turbo SE 0-4-4 from *Ascophyllum n.*, Logic Alliance Inc., Kentville Nova Scotia); fish fertilizer 15 ml (Nutrifish SE 2-3-1, North Atlantic fish, Pioneer Organics, Nova Scotia).

At each experiment, multiple brewers from the same manufacturer were started at the same time, following the same recipe and procedure, but one variable was tested for impact on final microbial content. Samples of finished tea were collected and sent via courier to Soil Foodweb Inc. Canada (Vulcan, Alberta, http://soilfoodweb.ca/). Laboratory analysis was conducted by direct microscopy 48 to 72 hours after sampling. Dilution plates were used to count number of individuals and staining of sub-samples to distinguish active organisms.

RESULTS AND DISCUSSION

One brew was recopied over 18 experiments for the “Bobolator” brewer (Table 1) and nine experiments for the “K.I.S.” brewer (data not shown). Microbial content of finished teas was used to assess consistency of the same person using the same brewer and the same recipe. Results for each brewer show fairly constant numbers of bacteria and fungi from experiment to experiment but high variation in protozoa numbers (flagellates and amoeba).

Compost is added to compost tea to supply the majority of micro organisms such as bacteria, fungi and protozoa. In this project, results indicate higher total fungi in tea prepared with one compost source compared to other compost sources (Table 2). There were high variations in number of protozoa, but no difference in total bacteria or active fungi.

Vermicompost is a result of earthworm’s activity to digest plant residue. In this project, results indicate highly variable results. Number of flagellates was lowest in the tea prepared with vermicompost only and highest in the tea prepared with a combination of composted yard waste and vermicompost (Table 3). Total fungi, active fungi and active bacteria were highest in tea prepared with vermicompost only.

Compost can be “activated” ahead of brewing to increase fungal content, which is then transferred into the tea. In this project, longer pre-activation time resulted in a linear increase in the number of flagellates (Table 4). Number of fungi (active and total) was highest in tea prepared with compost activated for 8 h before brewing. Using a larger amount of activating material resulted in higher number of fungi (data not shown).

Total brewing time is established to maximize multiplication of microorganisms while food additives are available. In this project, one brew was prepared and samples collected at various times then stored in a refrigerator until laboratory analysis. Longer brewing time resulted in a linear increase in number of flagellates (Table 5). There was also a linear increase in number of total fungi, amoeba and ciliates, but no change over time in number of total bacteria or active fungi.

Humic acid is a component of humus, along with fulvic acid and humin. It is added to compost tea as a “food source” to stimulate growth of beneficial fungi present in the start-up compost. In this project, the “standard” recipe of 30 ml per 15 L water resulted in the highest number of total fungi (Table 6). Number of active fungi was also highest in the standard recipe, but there was no treatment impact on number of bacteria, flagellates or amoeba. No fungi were recovered from another tea brewed with humic acid alone without compost (data not shown), indicating the humic acid did not contribute fungi to the tea.

Cold water kelp (specifically *Ascophyllum nodosum*) is added to compost tea as a “food source” to stimulate growth of both bacteria and fungi, and to add nutrients for plant foliage and roots. In this project, the amount of kelp had no impact on total fungi except at the 4X standard rate (Table 7). Number of active fungi was also highest in the higher application rate, but there was no impact on number of bacteria, and number of flagellates was higher in all treatments with seaweed, regardless of the rate used. No fungi were recovered from tea brewed with kelp alone, in the absence of compost (data not shown).

In other brews, increased amounts of fish fertiliser resulted in a linear increase in total fungi (data not shown). There was no treatment impact on bacteria, flagellates or amoeba.

CONCLUSIONS

Compost tea has potential to help suppress plant diseases. There is strong scientific evidence that actively aerated compost tea can prevent a number of plant diseases such as damping off and *Botrytis* mould. Best results are obtained when start-up compost is high quality. The active brewing aims to extract beneficial microorganisms found in the start-up compost; ingredients such as humic acid and kelp aim to stimulate population growth.

In this project, there was a high impact on final microbial content from the start-up compost and the duration of brewing time. There was a moderate impact from the use of humic acid and kelp. There was a low impact from the source of water and the clean-up of brewing equipment (data not shown).

All experiments were controlled but not replicated, preventing statistical analysis of most data. The results should be viewed as trends rather than absolute, as similar brews done under different conditions would likely deliver different results.

Replicated testing of compost tea microbial content is difficult. Microbial composition changes over time with changes in oxygen concentration and food additives. Different persons doing counts using direct microscopy may yield different results. Future work will require a method to stabilize microbial activity without affecting microbial composition.

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Tables

Table 1. Final microbial content[1] of actively aerated compost tea prepared with the commercial brewer “Bobolator 5 gallon”[2] using the same procedure and recipe.

Experiment	Active bacteria	Total bacteria	Active fungi	Total fungi	Flagellates	Amoeba	Ciliates
08-0160	39	9344	11	15	5753	3570	0
08-0161	53	9344	12	25	27725	272	0
08-0163	48	7552	16	36	13863	277	1
08-0166	31	8448	13	25	---	---	---
08-0170	36	8192	29	35	460	1525	5
08-0171	30	7936	5	16	27725	277	4
08-0174	40	6528	17	29	13863	2772	13
08-0252	42	1728	1	7	27725	2772	5
08-0358	36	755	5	20	3164	57536	0
08-0360	75	781	29	36	4606	46060	0
08-0364	51	1011	48	50	46	4606	0
08-0376	50	10240	110	197	42635	4263	13

[1] Biomass in ppm for bacteria and fungi, actual number per ml of solution for flagellates, amoeba and ciliates.
[2] “Bobolator”, North Country Organics, Vermont, http://www.dirtworks.net/Images/BrwrManBitti-1.pdf.

Table 2. Final microbial content of actively aerated compost tea prepared with different compost products in the commercial brewer "Bobolator 5 gallon".

Compost product [1]	Bacteria active	Total bacteria	Fungi active	Fungi total	Flagellates	Amoeba	Ciliates
Glengrow	38	5888	5	13	5753	4263	4
Nature's Gold	35	4736	6	14	152495	575	13
Byland young	44	5504	7	18	13863	1386	4
Byland mature	51	7808	8	35	138	46	5

[1] Glengrow is composted yard waste (City of Kelowna, British Columbia); Byland is proprietary composted yard waste (West Kelowna, BC), Nature's Gold is composted sewage sludge (Lake Country, BC).

Table 3. Final microbial content of actively aerated compost tea prepared with compost and vermicompost mixtures in the commercial brewer "Bobolator 5 gallon".

Product (g) per 15 L water[1]	Bacteria active	Bacteria total	Fungi active	Total fungi	Flagellates	Amoeba	Ciliates
Vermicompost 285 g	50	2432	28	37	5	460	0
Yard waste 485 g	24	3904	6	14	4606	277	4
Vermicompost 140 g + yard waste 240 g	25	6656	18	18	8318	1386	1
Vermicompost 285 g + yard waste 485 g	30	7936	5	16	27725	277	4

[1] Vermicompost is Nurturing Nature Organics (Lake Country, British Columbia); Glengrow is composted yard waste (City of Kelowna, British Columbia).

Table 4. Final microbial content of actively aerated compost tea prepared with compost pre-activated with oat flour[1] in the commercial brewer "Bobolator 5 gallon".

Pre-activation[2]	Bacteria active	Bacteria total	Fungi active	Fungi total	Flagellates	Amoeba	Ciliates
At start of brew	197	10112	210	241	4606	2772	1
8 hours before	271	8960	539	656	4606	2772	0
4 days before	246	9856	110	264	27725	3570	5
6 days before	292	9856	92	130	57536	13863	4

[1] Oat flour (product Oat Meal Cereal for Baby from Healthy Time) was mixed at 12% concentration (90 g) into the "standard" mixture of composted yard waste and vermicompost (770 g).
[2] Oat flour was mixed with the compost for the duration listed before making the tea.

Table 5. Final microbial content of actively aerated compost tea brewed for various duration in the commercial brewer "Bobolator 5 gallon".

Total duration of brewing[1]	Bacteria active	Bacteria total	Fungi active	Fungi total	Flagellates	Amoeba	Ciliates
1 hour	33	1216	5	7	5753	696	4
5 hours	38	4224	5	5	4606	426	5
12 hours	50	5120	3	5	4606	1386	13
24 hours	30	5504	8	18	13863	575	13
48 hours	38	7552	7	29	57536	3164	46
70 hours	30	6144	4	34	138630	3570	46

[1] Samples collected at different times from the same tea. Compost ingredients were removed 5 hours after start.

Table 6. Final microbial content of actively aerated compost tea brewed with varying amounts of humic acid in the commercial brewer "Bobolator 5 gallon".

Humic acid[1] per 15 L water	Bacteria active	Bacteria total	Fungi active	Fungi total	Flagellates	Amoeba	Ciliates
0 ml	46	8576	16	23	5753	831	0
15 ml	49	10752	9	19	5753	1386	0
30 ml	50	8960	26	72	5753	575	0
120 ml	39	9344	11	15	5753	3570	0

[1] Product Multi-dynamic Humic Extract, Tecologic Products Ltd. (Calgary, Alberta).

Table 7. Final microbial content of actively aerated compost tea brewed with varying amounts of kelp in the commercial brewer "Bobolator 5 gallon".

Kelp [1] per 15 L water	Bacteria active	Bacteria total	Fungi active	Total fungi	Flagellates	Amoeba	Ciliates
0 ml	41	8832	10	20	5753	575	1
15 ml	38	10240	24	28	35700	1525	2
30 ml	53	9344	12	25	27725	2772	0
120 ml	31	9856	102	88	27725	426	0

[1] Product Turbo SE 4-0-0 containing *Ascophyllum nodosum* seaplant (Kentville, Nova Scotia).

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