Aerated Compost Tea: A Field Guide to Production Methods, Formulas and Application Protocols

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This study has been made possible through a Western SARE grant we received in 2015. One of the first steps we did was institute a "Brain Trust" of knowledgeable individuals to act as an Advisory Council to guide our research and provide valuable feedback. To this group of four individuals I am grateful:

John Garlisch is the County Agent for the Bernalillo County Cooperative Extension Service, the extension agency for New Mexico State University. John has acted as Technical Advisor and has many years in supporting agricultural producers in New Mexico, as well as being a farmer himself.

Walter Dods has worked for Soilutions for 15 years. Soilutions is the largest company in New Mexico to produce compost approved for use in certified organic gardens and farms and has been doing so for 20 years. Walter is THE expert in organic compost in New Mexico and is knowledgeable in compost and compost tea production. We used Walter's commercial aerating compost tea brewer for all compost tea production.

Fred Koster, raised on a farm, a lifelong gardener and recently a commercial farmer is a retired physician and microbiologist. As a commercial farmer using sustainable and organic practices, Fred is committed to helping develop a compost tea production process that is both effective, safe and in compliance with FSMA Standards.

Matthew Draper has been a partner at North Valley Organics for the past three years and has been a mainstay in the day-to-day operations of our farm. Without his calm perseverance, focused attention and deep dedication to biological and sustainable farming, this project would never have left the ground. (or made it into the ground...)

A special note of appreciation goes to Rudy Garcia and all the staff at the New Mexico USDA NRCS office. Rudy has been a champion of Soil Health for 25 years and has recently taken a position as Regional Coordinator for the newly organized "Soil Health Division" within the NRCS. Rudy's tireless efforts to promote biological farming and the critical role of the living biosphere has been an inspiration to all of us.

Finally, I could not have completed this work without the ongoing support of my lovely wife, Sylvia. With forbearance and an amused tolerance - "Why is there a bowel of dirt in the closet?!?"- Sylvia has survived any number of planned (and accidental) events.

Background and grant focus

In January, 2011 the Food Safety and Modernization Act (FSMA) was signed into law, with a 5 year review period for receiving feedback and modifying the regulations. FSMA covers a wide range of issues regarding food safety and agricultural production and consists of thousands of pages of regulations, rulemaking, etc. FSMA was promulgated by the Food and Drug Administration (FDA) and grants broad authority to the FDA to regulate its Standards, including regulating on-farm production activities.

One part of FSMA- The Final Rule for Produce Safety- is the focus of this paper. The Final Rule was published in November, 2015 and went into effect in February, 2016. There is a timeline for beginning of enforcement activities that ranges from 2016-2020. The Produce Safety rule establishes: "Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption". In subpart F of this rule, compost and compost tea is addressed.

This paper does NOT discuss whether a particular farm is exempt from FSMA. The question of who is covered by FSMA, farm size, produce sales, timeframe for compliance, specific exemptions under FSMA- these are all important questions, but not addressed here. Our focus is providing information to farmers who have decided they wish to comply with FSMA Standards.

Disclaimer: Although we have made our best efforts to understand the FSMA rules and Standards, we cannot guarantee that following the processes outlined in this paper will guarantee compliance under FSMA. The law is too new, with too many questions for us to make this claim. We have outlined what we believe to be a thorough and well documented process for making compost tea that complies with FSMA, but make no guarantees that any regulatory body will accept our process as valid.

In the last few years there has been a resurgence in interest in biological farming- maximizing the natural biologically based processes that occur on a farm, to the benefit of the farmer and the farm ecosystem. Elaine Ingham, the Rodale Institute, Cornell University College of Agriculture and the Sustainable Agriculture Research and Education program (SARE), to name a few, have long championed the critical role microbes play in soil health and improving the farm eco-system.

New research is emerging about how these microbes are present at every level of plant production and play a critical role in plant growth, carbon cycling, pathogen suppression and a healthy environment. This report, however, does NOT address the effectiveness of compost tea in improving plant health, yield, pathogen suppression, etc. Nor does it address how to properly make compost that complies with FSMA or the National Organic Plan (NOP) Standards for making compost.

The specific focus of this report is how to implement an on-farm process for making aerated compost tea that meets the newly promulgated Standards for "biological soil amendment of animal origin" under the Food Safety and Modernization Act (FSMA). We outline what a farmer must do on his own farm to meet FSMA standards for compost tea safety.

Food Safety Modernization Act (FSMA)

In recent years food safety on farms has become increasingly important. Many vendors are moving in the direction of requiring farmers to be certified in "Good Agricultural Practices" (GAP). There are many excellent programs for on-farm food safety. The USDA website is a good place to start: https://www.ams.usda.gov/services/auditing/gap-ghp.

Making pathogen free compost tea on-farm is a subset of an overall program to minimize food safety concerns on the farm. Many of the steps needed to make safe compost tea- washing hands, material storage, etc- are also good general practices for ensuring farms comply with GAP.

Under the Produce Safety rule "biological soil amendment of animal origin" is defined as:

> *"A biological soil amendment of animal origin" means a biological soil amendment which consists, in whole or in part, of materials of animal origin, such as manure or non-fecal animal byproducts, or table waste, alone or in combination. The term "biological soil amendment of animal origin" does not include any form of human waste (see proposed § 112.3(c))."*

The rule makes a distinction between raw manure and compost:

> "*We are proposing to use the phrase "untreated biological soil amendments of animal origin" as a category that includes raw manure (see proposed §§ 112.3(c) and 112.51(a)). We use the term "treated biological soil amendments of animal origin" to include treatments that meet the requirements of the standards presented in subpart F of the proposed rule (see proposed § 112.51(a)). To further alleviate confusion, we use the term "compost" as a verb, to mean the act of composting, and do not use it as a noun to describe a soil amendment that was treated by a composting method."*

See Attachment "A" for a summary of the Final Rule on Produce Safety. (also called the Final Rule or Produce Safety Rule). The Final Rule sets Microbial Standards listing the quantity of pathogens allowed for "biological soil amendment of animal origin". i.e. compost. These Microbial Standards are:

> ***Microbial Standards for Treatment Processes (Proposed §§ 112.54 and 112.55)***
> *The following treatment processes would be acceptable for biological soil amendments of animal origin used in the growing of covered produce under the proposed rule.*
>
> *1. (Proposed §§ 112.54(a) and 112.55(a)) Scientifically valid controlled physical processes (for example, thermal), chemical processes (for example, high alkaline pH), or combinations of scientifically valid controlled physical and chemical processes that have been demonstrated to satisfy each of the following microbial standards:*

Listeria monocytogenes	***Not detected using a method that can detect one (1) CFU per five gram analytical portion***
Salmonella species	***Less than three (3) MPN per four grams of total solids (dry weight basis)***
E. coli O157:H7	***Less than 0.3 MPN per one gram analytical portion***
Fecal coliforms	***Less than 1,000 MPN fecal coliforms per gram of total solids (dry weight basis).***

Definitions: "CFU" means "colony forming unit" and "MPN" means "most probable number"

Using a "Validated Process"

In the Final Rule, the FDA does not specifically discuss compost tea although it is clearly a "biological soil amendment of animal origin". As such, it would be covered under the Microbial Standards. One can argue that a compost tea made from a compost that has no animal products in it and which does not receive any kind of additives as food during the brewing process does not meet this definition. However, we have opted to apply the Microbial Standards to all compost tea we produce for the following reasons:

1. How can one be certain that the source of compost has no "animal" products?

2. "Animal products" include such food additives used during brewing as fish emulsion, worm compost and bone meal, all potentially useful.

3. Even in 100% vegetable based compost, can you be absolutely certain that no fecal or animal matter has entered the compost stream? bird droppings? Insects?

The FDA is sensitive to the question of whether or not the Final Produce Rule requires on-going testing of compost or compost tea in order to meet compliance. The Final Rule itself does not address this, but in a monograph titled:

"*Frequently Asked Questions and Answers for Proposed Rule: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption"* (see appendix B)

The FDA responds:

" Does the proposed rule establish testing requirements for soil amendments?
No. The proposed microbial standards for treated biological soil amendments in § 112.55 are not meant as lot-by-lot microbial testing requirements. Rather, they are intended to provide the standard against which treatment processes would be required to be validated. ***A validated process, when properly implemented and monitored, would be expected to meet the listed microbial standards.*** *The person applying the treatment process would need to monitor the physical parameters of the process (e.g., temperature of a compost pile) to ensure that they meet the conditions under which the process was validated. Farms would be able to use treatment processes that are validated to meet the relevant microbial standard without needing to test the end products of their treatments to confirm that the microbial standard was achieved."*

Our Interpretation: The explanation above by the FDA is confusing. Our understanding of this clause is as follows:

1. For compliance purposes, compost tea must meet the Microbial Standards as "a biological soil amendment of animal origin".

2. An on-farm process for producing compost tea that has been validated, would be acceptable proof that the microbial Standards are met- without batch-by-batch testing.

3. The best way, however, to validate an on-farm brewing process is... microbial testing.

In other words, if a farm develops a process for brewing and using a compost tea, documents this process, then tests the results to demonstrate compliance with the microbial standards, ***as long as this same process is followed, it is not necessary to test each batch.*** This is why we have developed such detailed documentation of every step in brewing tea. The one-time documentation of every step in brewing becomes our "validating" process. Having tested our compost tea once and demonstrating there are no pathogens, we feel on solid ground that every subsequent batch will be pathogen free.

How long is our "validated" process good for? In our interpretation, as long as the process steps have not been altered, the validation is open ended. Of course, if any of the process steps change, this would require a new "validation" test (i.e. microbial testing) to then validate the "new" process. What constitutes a change in process? We are applying a "common sense" standard to this question. Major changes such as source of compost, source of water, different food additives used or different brewer - these would all constitute "new" steps requiring validation. Temperature changes, brew time, and storage location are examples of variations that would not require new validation.

Pathogen Prevention

The intention behind the FSMA is to keep our food supply safe and prevent pathogens from getting into the food stream. On the farm, pathogens can be introduced into the food stream primarily by two vectors: introduction of pathogens from outside the farm and failing to prevent natural pathogens that are present on the farm from entering the food stream. Both of these vectors can occur while brewing compost tea. By being aware of every step involved in tea brewing and understanding how pathogens move in the farm ecosystem, we are demonstrating a larger commitment to food safety. For our farm, this is the primary reason for documenting our tea brewing process and "validating" our process through testing: the confidence and certainty that we are doing everything possible to deliver to the public a safe product. Even if not required by FSMA, we would implement the exact same steps in brewing compost tea.

There is another great benefit to becoming immersed in the details of compost tea brewing: a farmer becomes much more aware of the microbial life on the farm in all its aspects. Once you start "thinking like a microbe" it begins to affect how you see many operations on the farm.

Being aware of overall farm food safety practices, we can list several factors that will help minimize the possibility of pathogens in compost tea:

1. Personal hygiene and worker health. Washing hands, not handling food products or compost when sick and wearing safety gear are no-brainers for food safety.

2. Assure that the component parts of compost tea contain no pathogens. The compost itself, water used and any materials added during brewing should all be pathogen free.

3. Cleaning and sanitizing are critical. During the brewing process we take precautions to assure that pathogens do not proliferate, but when brewing is complete, it is critical to clean and sanitize all areas that came into contact with compost tea.

4. Assure that the tea has enough oxygen. Pathogens tend to grow in environments with low oxygen (anaerobic) so assuring that our tea is properly aerated can go a long way to preventing pathogen growth.

Testing:

In order to assure that the finished compost tea is pathogen free it is important to begin with components that are pathogen free.

Water:

Water source is an important consideration in compost tea brewing. If municipal water is used, it is possible to obtain a water quality report to verify water quality.

For well water it is recommended to test for safe drinking standards as well as other parameters important in understanding how water affects microbes. For our validation process we tested our water for the following:

> Bernalillo County water quality analysis: total coliform, E. Coli, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, sodium, potassium, calcium, magnesium, chlorine, bicarbonate, total dissolved solids, pH and sulfate.
>
> In addition we tested for: arsenic, lead, iron and chloride

See Appendix E for test results. We used the following lab:

> Hall Environmental Analysis Laboratory
> 4901 Hawkins, NE
> Albuquerque, New Mexico 87109
> (505) 345-3975
> www.hallenvironmental.com
> Attention: Andy Freeman

Compost/compost tea pathogen testing:

When we began this project, we assumed it would be straightforward to locate a laboratory capable of testing compost and compost tea with the Standards required under FSMA. This has turned out to be quite challenging. Many laboratories test for E Coli, but very few have the capability to test for all 4 pathogens listed in FSMA. We have identified 2 laboratories- both in California- with full capabilities.

Primus Labs is a specialist in food safety testing. This work is an extension of their testing, auditing and quality control work around food safety. They are not a specialist in compost testing, but have the full laboratory capabilities to test compost and compost tea.

Control Laboratories in Watsonville, California, is a specialist in compost and are members of the US Composting Council. While food safety is not their specialty, pathogen testing for compost and compost tea is.

Primus Laboratories	Control Laboratories
2810 Industrial Parkway	42 Hangar Way
Santa Maria, California 93455	Watsonville, California 95076
(805) 922-0055	(831) 724-5422
www.primuslabs.com	www.compostlab.com
Attention: Adam Hughes	Attention: Mike Galloway

See appendix C and D for copies of test results.

Compost/compost tea quality testing:

Although this paper addresses the safety of compost tea, it is important to understand how the process of brewing tea affects the overall quality of the tea. Our goal in using compost tea is to inoculate our crops with the full diversity of microbes that perform beneficial functions. Elaine Ingham has been researching soil microbes for over 40 years and has developed excellent resources for evaluating the quality of compost tea. Through her seminars, writings, publications and webinars, she actively educates farmers in how to evaluate for themselves the quality of their compost tea. Information can be found at: www.soilfoodweb.com

Matt Slaughter worked with Dr. Ingham for many years and has developed testing protocols for compost/compost tea quality. Information at: www.earthfort.com

Appendix F and G have information on these 2 laboratories.

Compost tea basics

This paper describes a validating process for brewing "actively aerated compost tea (aact)". AACT is distinguished from other liquid compost products by 2 characteristics:

1. Compost is suspended in water, either free floating or in a mesh bag, and is then subject to air bubbles that simultaneously add oxygen to the water and by their aggressive movement, dislodge the variety of microbes- bacteria, fungi, protozoa and nematodes- from the surfaces of the compost.

2. Once these microbes are free in the water, they begin to feed and reproduce. The feeding and reproduction depends on several factors: available food sources, temperature, oxygen in the water and the proportion of various microbes.

Typically, bacteria reproduce at a faster rate than fungi. Probiotic bacteria thrive in an oxygen rich (aerobic) environment whereas pathogenic bacteria such as E coli. 0157:H7 thrive in an oxygen poor (anaerobic) environment. As microbes begin to reproduce, if there is adequate food sources and oxygen, the probiotic microbes dominate, consuming the pathogenic microbes and creating a rich broth of microbes that benefit plants and soil. If either the oxygen level drops OR the available food supply becomes inadequate, the pathogenic microbes can dominate. A simple "smell test" is a good indicator: a rich earthy smell is probiotic; a rotting putrid smell indicates pathogens.

The brewing process amplifies the microbes that already exist in the compost. Both probiotic and pathogenic microbes exist in any compost but a high quality compost that has reached 131 degrees F will have a preponderance of probiotic microbes. The single most important factor in making good compost tea is starting with high quality compost. Next in importance is maintaining at least 6 mg/L (milligrams per liter) of oxygen dissolved in the water. Oxygen consumed is proportional to the amount of biological activity, which in turn is affected by available food supply and temperature. Typical food sources that are added to tea that favor bacterial growth are simple sugars such as molasses and protein sources such as kelp and fish hydrolysate. Soybean, garbanzo bean and to a lesser degree oats are a protein source that favor fungal growth.

With experience (and testing and microscope work) you can begin to develop the expertise to brew tea that favor bacterial growth or fungal growth. Traditional wisdom is that annual plants benefit from bacterial dominant teas whereas perennial plants such as trees benefit from fungal dominant teas. Recent thinking, however, favors a "balanced" tea with high counts of both bacteria and fungi.

Brewing tea without additional food sources slows down the metabolic process and variations in oxygen level are less likely to favor the pathogenic microbes. Adding food speeds up metabolism yielding much higher microbe counts, but also making it critical that the brew never becomes anaerobic. For our validation process, we measured the dissolved oxygen level every 4 hours, based on a fixed amount of food additives. Many tea brewers have moved away from simple sugars such as molasses due to a concern that the rate of bacterial reproduction with this readily available sugar can outstrip the aerating pump's ability to supply adequate oxygen. Seaweed, kelp, humic acid- these food sources break down much slower thus giving a wider range of microbes the opportunity to feed and reproduce, and modulating the amount of oxygen consumed.

A note on temperature. Some brewers strive to brew at temperatures between 70-80 degrees F, regardless of the ambient air temperature, as this mildly warm environment favors microbe growth. It is possible to multiply the microbe population at a much faster rate at higher temperatures- assuming food source and oxygen level are maintained. This can shorten the brew time to 12-24 hours. However, there is a high rate of die off of microbes brewed at 80 degrees F sprayed into an ambient temperature of 55 degrees F, such as might be the case in early spring or fall. To avoid this issue, we brew at the ambient temperature we are applying at, but modify the brew time for colder weather, sometimes brewing as long as 48-72 hours. The critical measurement is dissolved oxygen level.

Compost Tea Brewing Process at our farm

Outlined below are the steps we followed at our farm to brew compost tea. In dealing with microbes, small differences in process can make a big difference in outcome. The process of brewing compost tea is similar to what microbiologists do in million dollar labs. They just do it with more precision, controlling for more variables. In order for an on-going brewing process to be considered "valid", each step as outlined in the validation process needs to be followed every time a new batch of tea is made. The degree to which this process is more or less specific reflects the degree of specificity the farmer agrees to follow in the

day-to-day brewing of compost tea. As a rule of thumb don't make your validation process more complicated than you are prepared to follow in the daily brewing of compost tea. On the other hand, if you become inspired and enamored of how small changes affect tea quality, by all means take as much time and energy to explore this. The hidden world of microbes is infinitely fascinating and the more deeply you become involved, the better understanding you will gain about the overall functioning of your farm ecosystem. Our validation process is more detailed than what the average farmer will probably follow, so feel free to simplify. In the end, there are 2 criteria that determine whether your compost tea brewing process is "validated":

1. That you routinely follow the steps outlined in your validation process and

2. The test results for your compost, water source and finished compost tea fall below the microbial standards issued by FSMA.

Part One: Farmer Self Assessment

As we began to study the factors that can potentially affect the safety of compost tea, we began to expand the parameters we tracked. Each farmer that contemplates documenting and validating their on-farm brewing process can benefit from familiarizing themselves with the variety of details that can affect the process of brewing. Outlined below is a self assessment that will guide the farmer in deciding what level of detail to track in creating their own validation process. The completed self assessment also becomes part of the documentation required in the validation process.

This section reviews the reasons for using compost on the farm, and asks the farmer to think through the logistics of production, storage, transportation and impact on organic certification. Attachment H is the full Self Assessment.

Compost:

1. Do I plan to use compost in my farm operation? _____Yes _____No
If No, skip to Compost Tea section. If Yes, continue

2. How do I plan to use compost on my farm operation?

3. What are the outcomes I expect to see using compost?

4. Is my farm certified organic, or plan to be certified organic? _____Yes _____No

5. What is the source of the compost I plan to use:
_____ made on the farm. Following organic standards? ____Yes _____No _____NA
_____ purchased from off-farm. Approved for organic use? ____Yes _____No ____NA
_____ obtained free off-farm. Approved for organic use? _____Yes _____No ____NA
_____ both farm made and purchased

6. If purchased/obtained off-farm, name, address and phone of supplier(s):
- Does supplier have any credentials or documentation of compost quality? (i.e. member of US Composting Council, organic certification, compost test results, etc)
_____Yes _____No

- Do I have copies of documents? _____Yes _____No
- How is compost transported to farm?
- Is transport vehicle/container inspected before loading for possible contamination?
_____Yes _____No

- Is compost covered during transportation? _____Yes _____No

7. Upon arrival to farm, is compost used immediately or stored on-farm?
_____ used immediately _____ stored and used later _____ both

If stored, location and manner of storage:
Is stored compost covered: _____Yes _____No
If yes, manner and type of covering:

8. For stored compost, what is maximum length of time before compost is used as compost or for making compost tea?
_____ Days _____ Weeks _____Months

9. For on-farm produced compost:
Describe your compost making process, including inputs, timeframes, process and storage:

- Storage location of on-farm produced compost and manner of storage:
Is stored compost covered: _____Yes _____No
If yes, manner and type of covering:

- Is on-farm produced compost certified organic? _____Yes _____No
- For on-farm produced compost, what is maximum length of time before compost is used as compost or for making tea?
_____ Days _____ Weeks _____Months

This section addresses use of compost tea and requires the farmer to identify the source of the compost, water, and type of brewer. Details on testing are also required.

Compost Tea:

1. Do I plan to use compost tea in my farm operation? _____Yes _____No

2. How do I plan to use compost tea on my farm operation?

2A. Do I plan to use a bacterial dominant, fungal dominant or balanced tea? Why?

3. What are the outcomes I expect to see using compost tea?

4. Is my farm certified organic, or plan to be certified organic? _____Yes _____No

5. What is the source of the compost I plan to use in making compost tea:
_____ made on the farm. Following organic standards? ____Yes _____No _____NA
_____ purchased from off-farm. Approved for organic use? ____Yes _____No ____NA
_____ obtained free off-farm. Approved for organic use? _____Yes _____No ____NA
_____ both farm made and brought in

- Have I tested the compost for pathogens? _____Yes _____No

6. What is the water source for making compost tea?

7. Have you tested the water using drinking water standards? _____Yes _____No
- if Yes, name and address of laboratory:

- What was water tested for/what Standards were used?

- Were test results positive for pathogens or prohibited materials? _____Yes _____No
If Yes, explain:

8. In making compost tea I will use compost that has been:
_____ Brought to farm fresh with each batch of tea, i.e. not from farm-stored compost
_____ From compost previously brought/made at farm and stored on-farm.
- maximum length of time stored compost will be used for tea:_____

9. I will be using the following brewer (include make, model, description, gallon capacity, air pump capacity):

10. At the completion of the brewing cycle, I will be using the compost tea within_____ hours and _____ minutes from the time I stop aerating the tea.

The final section outlines some of the application methods.

Application:
I will use the following methods for applying the compost tea:

Application method	**Application Equipment**	**Water dilution ratio**
Spray foliar feed plants	4 gal backpack sprayer	3:1
side dress at base of plants	5 gal bucket with pail	5:1
liquid drench of soil	40 gal. tractor mounted sprayer	5:1
injection through drip lines	Injector	Not diluted (1:1)
root soak for greenhouse transplant starts	5 gal bucket with pail	Not diluted (1:1)
other application method		

Part Two: Infrastructure Preparation

Once the farmer has reviewed their use of compost on the farm and decided they want to move forward with making compost tea, there are many preparatory steps necessary prior to beginning the brewing process. Attachment I is the full Step-by-Step Preparation. Photos below illustrate each section.

1. The most important factor in determining the quality and safety of compost tea is the compost. High quality compost, free of pathogens and properly cured is essential. The brewer used is also a critical component. The air pump and diffuser on the brewer must be able to deliver adequate oxygen to the water such that the dissolved oxygen level never falls below 6 mg/L, and preferably stays at 8mg/L or above all during brewing. Even with a good pump if the diffuser becomes clogged, air distribution can be restricted.

Decide on type and model of brewer to be used.
- what brand of tea brewer will you use?
- what are the components of the brewer?
- what is the air pump capacity in cubic feet/minute (cfm)?
- what type of diffuser is being used?
- turbidity level: is pump able to move brew around sufficiently to dislodge microbes?

- is turbidity level adequate to assure no "low oxygen" zones
- is the brewer easy to clean?
- what type of strainer will you use?
- what is mesh size of strainer?
- can you obtain more strainers as needed?
- who is your supplier for strainers?
- besides the brewer, what additional implements are used in the brewing process?

Growing Solutions 10 gallon brewer

2. Maintaining clean and uncontaminated brewing equipment is essential. A stable power source for the pump is important. A brew can become anaerobic very quickly if the aerating pump goes out.

<u>Decide on location where brewer and supplies will be located.</u>

- where is the brewer stored?
- is storage in the open or closed area?
- is the brewer stored covered or uncovered?
- is the brewer stored in the same location at all times?
- during brewing, what is the location of the brewer?
- is the brewer covered during brewing
- what is the power source for the aerator motor?
- could you lose power from this power source?
- how would you know if you lost power?
- what is elevation of your brewing location?

indoor storage area for equipment

covered brewing area

3. For those farmers using compost they themselves produce it is critical to assure a high quality product. If the operation is certified organic, then very specific records are required.

Decide whether on-farm or off-farm compost will be used. If on-farm compost:

- do you plan to use the compost as compost on the farm, or just to make tea?
- do you have a written log documenting your steps for making compost?
    - are you certain that the minimum temperature is reached?
        - how do you measure this?
        - how do you document this?
    - are you certain that the minimum temperature timeframes are met?
        - how do you measure this?
        - how do you document this?
- Is your operation certified organic?
    - if yes, do you follow the NOP Standards for producing compost?
    - do you have documentation to demonstrate compliance with NOP Standards?
    - If not certified organic, do you follow the FSMA standards for making compost?
        - which Standard do you follow?

Acceptable treatment processes include any scientifically valid controlled physical, chemical, or biological process – or a combination – that is validated to satisfy certain microbial standards.

Composting is considered a common biological process, and validated composting methods include:

1. Static composting that maintains aerobic (*i.e.,* oxygenated) conditions at a minimum of 131 °F (55 °C) for 3 consecutive days and is followed by adequate curing; and

2. Turned composting that maintains aerobic conditions at a minimum of 131 °F (55 °C) for 15 days (which do not have to be consecutive), with a minimum of five turnings, and is followed by adequate curing.

Per FDA's definitions, curing may or may not involve insulation, depending on environmental conditions.

4. Many farms may choose to purchase certified organic compost for the purpose of making compost tea. If so keeping accurate records is important.

Decide on off-farm supplier of compost.

- who is the vendor/source of the compost?
- how is compost transported to farm site
    - in a container?
        - was container new/unused or used?
            -if no, was container cleaned/sanitized prior to use?
        - was container covered during transport?
    - if in a truck bed, was bed cleaned or sanitized?
        - was batch covered with a tarp?
    - if delivered by vendor, was batch covered?
    - how is batch offloaded from delivery vehicle?
    - where is compost stored?
    - what was date of delivery?
    - what time of day did delivery occur?
    - what was duration of transport?
- was batch rained/snowed on?
- any unusual occurrences during delivery?

- was sample from batch tested for microbes by supplier?
- was sample from batch tested for pathogens by supplier?
- do you have a written receipt from supplier for purchase?
    - does receipt show:
        - date purchased
        - date delivered
        - amount purchased/delivered
        - cost?
        - vendor name, address, phone #?
        - description of compost/product name?
        - organic designation?
        - other information?
    - is receipt stored in a safe place?
        - what is location of stored receipt?
        - how long do you keep the receipt?
    - is this batch being used in a certified organic operation?
        - do you have documentation approving this product for organic use?
            - what is location of this documentation?


Buying compost and transporting to farm

5. Storage of the compost is important. Compost needs to be covered to prevent contamination from animals but also in such a manner that air can circulate around the compost.

<u>Compost storage at the farm</u>

- what is the location where compost used for compost tea is stored?
    - is it always stored in the same location?
    - is storage out in the open or in a contained building/structure?
- is the compost covered?
    - how is the compost covered, with what material?
        - is the covering applied in such a manner to allow access to air?
        - what assurance is there covering will not be removed/blown away?
    - is the compost completely covered or partially covered?
- do you use the same stored batch as direct applied compost and for compost tea?
- how often is this batch replenished?
- what is the longest timeframe that tea will be made from a batch of compost?

covered compost storage at the farm

6. Assuring pathogen free, chlorine free water is critical to quality compost. Special Note: well water coming directly from the ground is often at 4 mg/L or less of dissolved oxygen when first pumped out. Running the aerator pump for 1-2 hours prior to brewing will usually solve this problem.

Decide on source of water to be used in compost and have water tested.

- what is source of water used in brewing?
  - if city tap water, is it chlorinated?
    - how do you remove the chlorine prior to making compost tea?
    - do you have access to city water reports that document water is safe?
- what laboratory will do the water testing?
- has water been tested for following parameters:
  - PH
  - presence of E coli 0157
  - total coliforms present
  - metals, including arsenic and lead
  - salts
- where do you store the water quality test results?
- what is the temperature of water as it comes from the source?
- is water used in tea brewing directly from source or is it stored prior to brewing?
  - how and where is it stored?
    - is storage covered?
    - has storage container been sanitized prior to storage?

Water quality test bottles provided by testing lab

water source- 200' deep well

7. Being able to test the dissolved oxygen (DO) level in the brew is a critical step in the validation process. Dissolved oxygen meters range in cost from $400-up, whereas DO test strips cost as little as $15.

Decide on testing methodology for dissolved oxygen (DO) and acquire supplies.

- will you acquire a DO meter?
  - make and model of meter?
  - has meter been calibrated?
  - has meter been compensated for elevation?
- if using test strips, who is supplier of test strips?
  - do test strips have adequate range indicators? (0 mg/L through 12 mg/L)
- have you completed a "static test" using water only with your brewer to measure DO levels at beginning of aeration and after one hour of aeration to assure that aeration is actually occurring?

Salifort brand DO test kit

Extech brand DO meter

8. For purposes of creating a validated process it is necessary to test at least one batch of finished compost tea. Most farmers will also want to have their compost tea tested for microbial levels. Dedicated enthusiasts will purchase a quality microscope and learn how to recognize the variety of microbes.

Choose which laboratories for pathogen and quality testing.

- will you do both pathogen testing and quality testing?
- which laboratory will you use for pathogen and quality testing?
  - is it necessary to open an account?
  - do you know exactly where to send the sample?
  - do you understand packing and shipping protocols to assure an accurate test?
    - do you have adequate packing and shipping materials?

Compost tea and packing supplies

Packed up and ready for overnight mailing

9. For those seeking a high fungal compost tea, pretreating compost assures that fungal microbes have a chance to get a jumpstart on growth.

Decide on pretreatment additives and supplier.

- will you be pretreating compost prior to making compost tea
- what additives will you be adding to compost as a pretreatment?
  - what is the proportion of compost, additives and water?
  - who is the supplier or source of additives?
- how long will you pretreat compost?
- where will you store compost during pretreatment?
  - will temperature be adequate for pretreatment? (65-80 degrees F.)
  - will pretreatment be covered, in the dark and undisturbed?

pretreating compost with oat flour

compost after 7 days- white is fungal growth

10. Adding food sources to the brew will greatly increase the microbial population BUT it is critical to assure that the DO level never falls below 6mg/L. Pathogen microbes are more likely to develop in an anaerobic brew. There are an endless number of food sources that can be added. There are also many premixed additives on the market.

Decide on brewing additives to be used and supplier

- will you be adding supplemental foods to brew?
- what materials will you be adding as food during brewing?
  - what is the source/supplier of additives?
- what are the proportions of additives used during brewing?
- at what point in brewing cycle are foods added?

food sources for microbes- Brand X blend and unsulphured molasses

11. For best results application of tea should be as soon after brewing as possible, preferably within 1 hour. As soon as brewing stops the brew no longer is being aerated and pathogenic microbes could begin to grow. Also microbes are susceptible to UV radiation, so timing of application is important.

Determine application equipment and methods

- what method of application will you use?
  - side dress, foliar spray, drip tape/sprinkler injection, greenhouse starts
- has your application vessel been used with any product that might inhibit microbe growth?
  - was vessel thoroughly cleaned prior to using with tea?
- will tea be diluted or applied at full strength?
  - what is temperature of water used for dilution?
  - is source for dilution water the same as water for brewing?
- will any additional materials be added to tea after brewing is complete?
- if foliar spray, is the spray orifice large enough to pass microbes?
  - does the sprayer have a built-in filter that might restrict tea flow?
    - is the filter finer than 400 micron mesh?
  - does the tea liquid make any 90 degree turns during spraying?
  - do you add any wetting agents to your spray mix?
    - are the wetting agents compatible with living microbes?
  - is the exit pressure from any nozzle greater than 20 PSI?
- if foliar spraying, is application during early morning or later afternoon to avoid strong UV radiation?

filling sprayer for foliar application

12. Cleaning of equipment is perhaps the most overlooked aspect of brewing tea. Most brewers have spaces that come into contact with tea that are hard to clean. Careful consideration of the cleaning and sanitizing process will minimize potential for pathogens. .

Acquire cleaning materials and equipment

- how do you assure tea liquid does not get into air line?
- do you clean all components with water and detergent prior to sanitizing?
- are all implements used in cleaning labeled for compost cleaning only?
- are all cleaning implements stored in a central location?
- are all implements used for compost cleaning only
- after cleaning components of brewer, are all components sanitized?
  - what brand and type of sanitizer do you use?
  - are brewer components allowed to air dry prior to placing in storage
- are you able to reach and clean all parts of brewer that come into contact with tea?
  - are there invisible or difficult to reach parts of brewer?
    - for membrane diffusers, do you disassemble diffuser?
    - for air stones, do you soak stone in sanitizer?
- do you maintain a "cleaning/sanitizing log"?
- do you clean the brewer and equipment within one hour of completing brewing?

cleaning supplies including StarSan sanitizer

13. Brewing process. Once everything has been prepared you are ready to start brewing.

Determine location of brewing and brewing procedures

- do operators follow general GAP practices while brewing?
  - i.e., not being sick, sneezing, coughing, etc?
  - do operators wash their hands prior to brewing?
- what is date of brewing?
- is brewing done in a controlled temperature environment or not?
  - is brewing done in a covered environment such as a building?
  - is brewing done in the same location every time?
- what is duration of brewing time?
  - do you have a log that notes batch #, date, brewing time, etc?
    - where is this log kept?
- is your brewer covered during brewing?
  - how is it covered?
- do you aerate the water in the brewer prior to adding compost?
  - how long do you aerate?
- do you measure the dissolved oxygen level in the brew during brewing?
  - at what intervals do you measure the dissolved oxygen level?
  - have you factored in your altitude in calculating oxygen level in your brew?
  - what type of aerator diffuser do you use?
    - have you verified the pores/orifices are not plugged up?
- what is ambient temperature when you begin brewing?
- what is the brew temperature when you begin brewing?
- what is the water temperature when you begin brewing
- what is the maximum temperature swing during brewing time?
  - what is high temp and low temp during brewing?
- how do you add the compost to compost tea brewer?
  - what implements do you use to transfer compost from storage area to brewer?
  - are these implements sanitized prior to use?
- do you use a strainer in the brewer?
  - what mesh size is the strainer
  - what is the configuration of the strainer and location within the brewer?
- what quantity of water do you use?
- what quantity of compost do you use?
- what quantity of additives do you use?
- what is the sequence of steps you take during brewing to add the water, compost and any additives?
- do you use additives during brewing?
- how is water added to the brewer?

14. Finally do you keep accurate records and record information for each batch brewed?

Part Three: Brewing Tea

Outlined below are the specific steps we take at North Valley Organics for brewing compost tea.

1. Pre-treat compost. Seven days prior to brewing we add oat flower and water to the compost, lightly cover and place in a dark area, usually inside the house to maintain a consistent 70 degree F temperature. This allows the slow growing fungal microbes to fully develop. When this compost is brewed we obtain a more balanced compost tea.

oat, soybean and garbanzo flour are good pretreatment food sources

a***fter 7 days growth***

2. Operator health check. As with all activities related to handling food crops, we only work when we are healthy and always wash our hands prior to brewing compost tea.

3. Prepare brewing area. We set up the brewer such that we will not need to move it after we add water and begin brewing. All equipment and materials are prepared. Note that brewing occurs in a covered area out of direct sunlight.

covered brewing area

4. Fill brew tank with water. Since we use well water that comes out of the ground at a uniform 55 degrees F. and a DO level of 4mg/L, we let the water sit for at least 8 hours to reach ambient air temperature of approximately 70 degrees F.

Well water initially at 4 mg/L DO- too low to brew

5. Prepare dilution water. If we plan to dilute the tea with water, we draw the water from the well at this point to allow it to warm up

letting dilution water sit- temperature and DO level rise

6. Aerate water for 2 hours. We turn the air pump on approximately 2 hours prior to brewing to raise the DO level from 4 mg/L to 10-12 mg/L. This also allows us to test our pump, assure that air diffuser is working correctly and verify our power source. If using municipal water, aerating will dissipate the chlorine.

raising the DO level by aerating

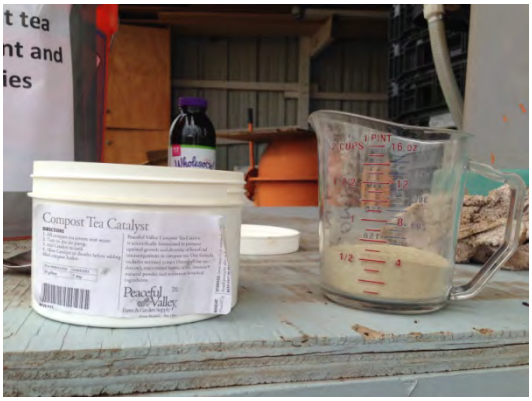
7. Test DO at beginning of brew cycle. We test the water for DO level prior to beginning brewing to assure level is 8 mg/L or higher.

DO level in brew water is raised to 10 mg/L

8. Add compost. We add the compost to our 1000 micron basket after the pump is turned on. This assures that no tea ever gets into the air line. The air line is harder to clean and can be overlooked. Pathogens can build up in the air line if it comes into contact with tea.

adding compost to brewer- note that basket is not too tightly packed

9. Add any food additives. We add food additives after 15 minutes of brew time to allow the compost microbes to disperse throughout the tea.



food additives during brewing

10. Allow to brew. We brew 24-48 hours, mostly based on ambient air temperature. In summer when temp is 80 degrees F we brew 24 hours typically. In fall or early spring with temp at 60 degrees F we often brew 36-48 hours. Experience (and testing) will be your guide to brew time.

Foam after 24 hours brewing- indicates good microbe growth

11. Check DO level during brewing. Particularly when you are brewing to validate your process, you want to check the DO level while brewing to document that the oxygen level never falls below the 6 mg/L level.

12. Decant brew into applicator. Note that we keep the pump running while decanting in order to prevent the tea from back flowing into the air tube.

backpack sprayer

13. Dilute brew if necessary. We use the water that has been sitting, not fresh from the well.

14. Apply tea. If used as a foliar feed, we try to avoid spraying midday. UV sunlight will kill the microbes. If using tea as a soil drench, root drench, side dress or transplant boost, time of day application is less critical. We have discontinued the practice of injecting tea through drip lines, as we don't want the possibility of creating a toxic biofilm inside the drip lines. Flushing followed by sanitizing the drip lines is too much work.

15. Clean all equipment. It is important to clean and sanitize all surfaces that have come into contact with tea, including hidden spaces and hard to reach areas. We use an acid based sanitizer used in the beer brewing industry. This material does not need to be rinsed off after application and is food surface compatible. The other major advantage of this product is that you can mix up a batch in a five gallon bucket and keep it stored for up to a month or more without it losing its sanitizing power.

16. Store equipment. Particularly when you are documenting your process for validation purposes, you will want to note where and how your equipment is stored.

17. Complete record-keeping. Complete records of each brew, particularly while validating your brewing process.

Brewing trials at our farm

For the purposes of this study, we worked with three sources of compost, representing three common sources small scale farmers might use for their composting operations:

1. On-farm produced compost using mixed inputs including plant residue, vegetable culls, grass clippings and most significantly, poultry manure and poultry bedding gathered from the chicken pen. This compost was created using a process of active turning and watering over a one year period to achieve thermal breakdown of plant matter. Scale is small with 2 piles approximately 1 cubic yard each.

2. Our second source of compost was a mid size commercial horse stable composting operation that utilized specially designed air injection piping and an automatic watering system with tractor turning of piles over an 18 month period. Inputs for this compost are primarily horse manure, alfalfa and hay used as bedding and feed, and a small amount of plant residue. This mid size operation produces approximately 30 cubic yards per year of compost.

3. Our third source of compost is a large scale commercial operation (Soilutions in Albuquerque, New Mexico, www.soilutions.net) whose primary input is plant residue with some horse manure. Temperature, moisture, process and curing time, chip size and other parameters are strictly monitored. Soilutions is the only source in Albuquerque for compost approved for use on organic farms.

Pathogen test results for compost:

Compost source	Pathogen test results	Comments
Chicken manure	Failed	fecal coliform greater than 1000 MPN
Horse manure	Failed	fecal coliform greater than 1000 MPN
Soilutions	Passed	4 pathogens below microbial standard

Because the chicken and horse manure based compost exceeded the standard for fecal coliforms, we eliminated these 2 composts for making compost tea. As a side note, however, we were curious whether the brewing process might have an effect on the total

coliforms, possibly reducing them to below the standard for food safety. We did brew compost tea and in both cases the total fecal coliform count came down below the 1000 MPN, indicating the tea was safe. Even so, we will not use these compost sources for tea.

The table below indicates the results of brewing compost tea with the Soilutions compost. We used 2 batches of Soilutions compost. The first batch was purchased on 10/19/15 and the second batch purchased on 7/14/16. From these 2 batches we ran tests with each batch- compost tea brewed with no additives, tea brewed with Brand X Tea Catalyst as food additives, and unsulphured molasses as food additive. All of our brewing followed the same protocols. We were evaluating 2 variables:

1. Whether or not the compost sitting idle for one year made any difference, and

2. Whether adding a food source affected the safety level of the tea.

The reason we made tea from a batch one year old is that we wanted to demonstrate in our validation process that we could make safe tea from compost produced off-farm, but stored on-farm for up to a year. This follows our farm practice of purchasing one load of compost per season, storing it properly and using it throughout the season to make compost tea. In addition we tested the Soilutions compost after one year, to verify that the compost had not developed any pathogens in the one year period stored at our farm.

Test results for Soilutions brand compost:

Compost purchase date	**Test Date**	**Pathogen Test Results**
10/19/15	10/22/15	Passed
10/19/15	9/1/16	Passed
7/14/16	8/30/16	Passed

Test results for compost tea brewed from Soilutions brand compost:

Compost purchase date	**Compost Tea brewing Date**	**Microbe Food additives used**	**Pathogen Test Results**
10/19/15	1/23/17	organic unsulphured molasses	Passed
10/19/15	1/21/17	None	Passed
10/19/15	1/23/17	Brand X Tea Catalyst	Failed
7/14/16	7/22/16	None	Passed
7/14/16	1/25/17	organic unsulphured molasses	Passed
7/14/16	1/17/17	None	Passed

CONCLUSION: We had passing test scores for both the old and new Soilutions compost tea when no food sources were added. We also had no problems when we added molasses. The only compost that failed was when we added Brand X mix. **Therefore, we have validated that we can use Soilutions brand compost that has been stored on-farm for up to one year either without additives or by adding molasses.**

The following Table lists the parameters for each step in our brewing process:

Process Specifications for brewing compost tea at North Valley Organics		
Albuquerque, New Mexico		
Category	**Parameter**	**Value**
Brewer	brewer make and model	Growing Solutions
	capacity	10 gallon
	pump make and model	Ecoplus model 728455
	pump flow rate at 0 PSI	2.3 cfm (cubic feet/min)
	storage location	container shelf
	mesh type	nylon basket
	mesh size	#18 mesh, 1000 microns
	bubbler type	3/4" pvc with 1/4" holes
	amount of compost per 10 gal batch	10 cups
	compaction level of compost in basket	low
water	water source	farm well
	initial water temp	55 degrees F
	initial water dissolved oxygen level (DO)	4.0 mg/L
	water ph	7.54
compost	compost source	purchased from Soilutions
	on-farm compost storage location	next to orchard
	compost pile age range	1-12 months
	is compost pile covered?	Yes
	delivery date of compost	7/14/2016
pre-activation	compost batch amount pre-activated	10 cups
	preactivation time	7 days
	preactivation temp	70 degrees F
	additive 1, per batch	fine oat flour
	Source	La Montanita Coop
	amount additive 1,per batch	1.5 cups
	additive 2, per batch	mined humates powder
	amount additive 2, per batch	1 cup
	Source	Mesa Verde Resources
	additive storage location	compost storage area
	amount water added	2 cups
	mixing process	in plastic bowl

Process Specifications for brewing compost tea at North Valley Organics		
Albuquerque, New Mexico		
Category	**Parameter**	**Value**
tea brewing	water aeration time, pre brew	2 hours
	DO level in water at beginning of brewing	10 mg/L
	minimum DO level during brew cycle	8 mg/L
	maximum DO level during brew cycle	12 mg/L
	water temp at beginning of brewing	60 degrees
	minimum brew temp during brew cycle	60 degrees
	maximum brew temp during brew cycle	90 degrees
	total brew time	24-48 hours
	food additives used	yes
	when food added	after 15 minutes of brewing
Additives	ingredients	humic acid/seaweed extract
	brand	Peaceful Valley Farm Supply
	rate	1/2 cup per 10 gallons
	ingredients	unsulfured molasses
	brand	Wholesome organic molasses
	rate	1/2 cup per 10 gallons
dilution	dilution water source	well water
	water aeration time	12 hours
	DO level at dilution	10 mg/L
	water temp at dilution	70 degrees F
	dilution ratio: foliar feed	2:1
	dilution ratio: side dress	4:1
	dilution ratio: soil drench	4:1
	dilution ratio: starts drench	1:1
application	boom sprayer T-Jet nozzle type	AIXR
	boom sprayer T-Jet nozzle #	04
	boom sprayer T-Jet nozzle color	red
	micron size opening	600 microns
	filter removed from nozzle?	yes
	boom sprayer maximum psi	15 psi
	was spray application during low UV?	yes
cleaning	cleaner material	dawn dishwashing soap
	sanitizing material	star-san brand sanitizer
	storage location	compost tea storage area
	cleaning/sanitizing timeframe	within 1 hour after brewing complete
documentation	brewing log completed	yes
testing	laboratory used	Primus Labs, California
	shipping method	overnight USPS
	shipping timeframe	within 1 hour of brew completion
	tea shipping container	1 Qt. plastic water bottle, 1/2 full
	shipping packaging	styrofoam with ice packs
	test results location	3 ring binder in office

Conclusion- Rules for brewing pathogen free compost tea

1. Assure that compost used in tea contains no pathogens.

2. Assure that water used in brewing tea contains no pathogens.

3. Assure that equipment used in brewing has been adequately cleaned and sterilized prior to every batch of tea.

4. Clean equipment and material immediately after brewing to prevent buildup of biofilm on brewer surfaces.

5. Use brewing equipment that is easy to clean and does not contain sharp corners where pathogens can accumulate and grow.

6. Assure that all parts including hidden parts of brewer are able to be cleaned and sanitized.

7. Assure that dissolved oxygen level in all parts of the brewer never falls below 6 mg/L.

8. Apply tea within one hour after completion of brewing.

9. Assure that brewer air pump has adequate and stable power supply to not shut off during brewing.

10. Assure that operators wash their hands prior to brewing and are not sick (coughing, sneezing, etc)

11. Do not use compost tea with any equipment that cannot be easily cleaned and sanitized, i.e. drip lines.

40 Gallon Brewer Design

Based on our experiences with a variety of brewers, we designed our own low cost 40 gallon brewer. Our brewer has the following characteristics:

1. A robust air pump that is designed for continuous use, producing 5.5 cfm air flow.

2. Quick release air tube that allows you to remove the pump while cleaning and also prevents tea from getting into air line.

3. Air line easily removed from diffuser for easy cleaning.

4. Custom made diffuser that sits on the bottom of the tank providing aeration over entire bottom of tank.

5. Diffuser parts easily disassembled for easy cleaning with a bottle brush.

6. Diffuser fits snugly into bottom of tank, yet is easily removable.

7. Tank is a 45 gallon heavy duty garbage can.

8. Custom attached spigot attached 8" from bottom of tank to allow settling of compost after brewing completed.

9. Compost floats free in tank- no strainer used.

10. Diffuser on bottom continuously agitates compost, preventing compost from settling on bottom of tank.

11. When air pump turned off, compost settles to bottom of tank within 5 minutes BELOW level of spigot.

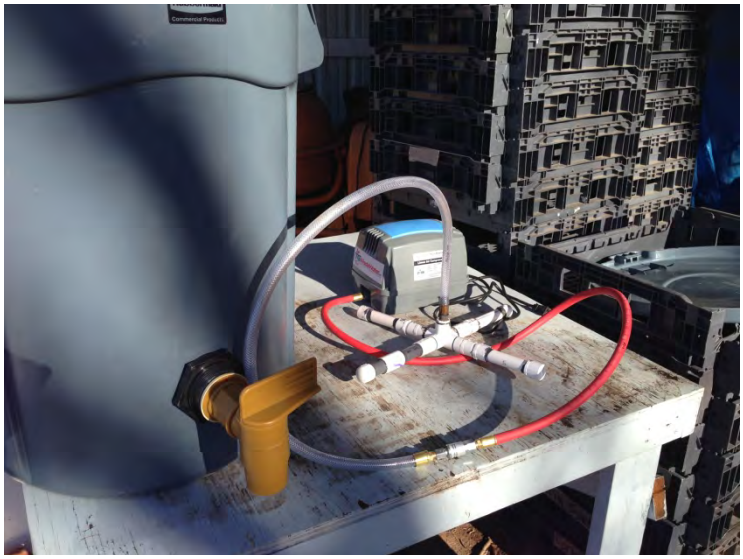
12. Large (2") low torque spigot for easy cleaning.

13. Super easy to clean: disconnect air hose, take out diffuser and wash out compost.

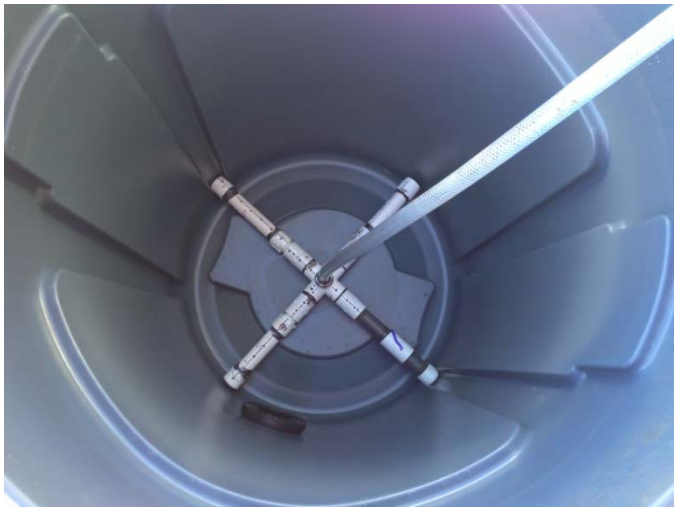
14. Diffuser parts and air line fit into a premixed 5 gal. bucket of sanitizer. After cleaning with dishwashing soap, dunk the parts in the sanitizing bucket, remove and let dry. Easy!

15. Low cost- entire setup approximately $300.

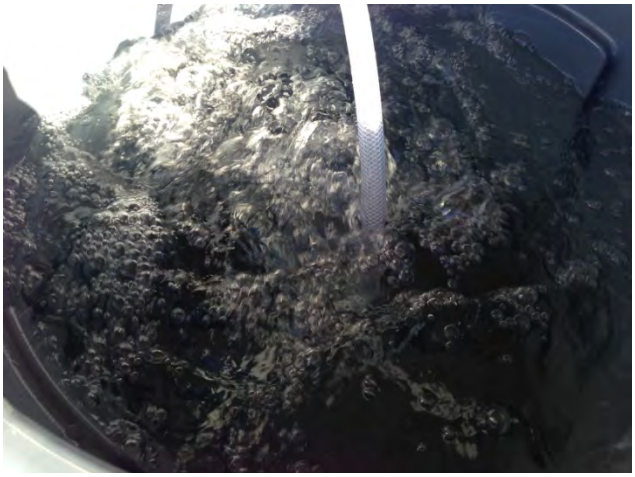
Brewer consists of 1) 45 gallon garbage can with spigot, 2) quick release air line, 3) pvc diffuser, 4) heavy duty air pump.



Diffuser assembled and attached to air line



Diffuser in bottom of garbage can



Robust aeration and agitation

Unit assembled and ready to go!

Conclusion-Validation process for brewing compost tea under FSMA

The FSMA is vague on what the exact requirements are regarding use of compost tea. It appears that teas fall under the generic category "treated soil amendments of animal origin" and therefore can be regulated by the FDA. At our farm we have chosen to adhere to the microbiology Standards as a precaution and to demonstrate a deeper commitment to food safety at the farm. Ultimately our motivation is to create a "culture of safety" at our farm to assure our customers we are doing everything possible to bring them a safe product.

Having "bitten the bullet" and decided to take the extra time and trouble to document our tea brewing process and create a "validated" set of practices, we have discovered many important lessons along the way, lessons we would not have learned if we had not decided to go down this path. Lessons not only about safe farm practices, but a deeper appreciation for the "life in the soil" that is the true richness of the farm. We are now experimenting with "designer" composts where we hope to isolate and multiply the probiotic microbes that are plant specific. We will use teas made from these composts to inoculate plants in the same family. We are learning about bacteria that exist on the leaf surface that help plants process nitrogen from the air (Azotobacter Vinelandii) and bacteria that exists in the soil that help roots process phosphorous (Azotobacter Chroococcum).

Is it possible to discover a microbe on the leaf surface that... repels squash bugs?!?

Who knows!

Useful Websites:

1. Elaine Ingham-	www.soilfoodweb.com
2. Elaine Ingham/Matt Slaughter-	www.earthfort.com
3. Tim Wilson-	www.microbeorganics.com
4. Tad/Leon Hussey-	www.kisorganics.com
5. Tad Hussey-	www.gardeningwithmicrobes.com
6. Elaine Ingham on-line classes-	www.environmentcelebration.com
7. Marc Remillard-	www.compostteamaking.com
8. General info on compost tea-	www.sare.org -use search function for compost tea www.calrecycle.ca.gov - go to compost tea home page www.biodynamics.com
9. compost tea blog-	www.compostjunkie.com
10. Information on brewers-	www.livingsoilsorganics.com www.growingsolutions.com www.willametteorganics.com www.composttealab.com

Websites addressing Food Safety, GAP, FSMA and compost/compost tea:

https://gaps.cornell.edu/educational-materials/decision-trees/soil-amendments
http://sustainableagriculture.net/fsma/learn-about-the-issues/manure-and-compost/
http://www.ffscn.net/blog/2016/2/28/compost-tea-in-the-age-of-food-safety
http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm334552.htm
https://www.farmcrediteast.com/sitecore/content/FCE%20Home/knowledge-exchange/Blog/todays-harvest/fsma-produce-safety-rule
https://www.ams.usda.gov/sites/default/files/media/Compost_FINAL.pdf
http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm247559.htm