ORGANIC FARMING RESEARCH FOUNDATION

Grant Report

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ORGANIC TEAS
FROM COMPOST AND MANURES

1. **AN OVERVIEW OF ORGANIC TEAS**
2. **RESULTS FROM CABRILLO COLLEGE RESEARCH PROGRAM**
3. **SUGGESTIONS FOR FIELD RESEARCH PROTOCOL**

by
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ABSTRACT

In this paper we review some of the pertinent research concerning organic teas, and note that the results of studies on the effects of such teas, especially as a biocide, is quite mixed. We believe this is due to the variable nature of both the organic feed stock and the methods of extraction. We also make some suggestions concerning a protocol for on-site research into the production and use of organic teas with suggestions for controlling feedstock and extractor variables infield experiments. Finally, we describe our experiences with prototype, simply-made, aerobic organic- tea extractors at Cabrillo College. Our results confirm those of others: that so-called anaerobic tea systems ... those in which organic stock is simply soaked in water.. are actually aerobic for the first 48 hours or so of extraction. After that, they BECOME anaerobic. In other words, aerated or "aerobic " systems simply extend the time of useful extraction by replacing OR adding oxygen into a system that would otherwise go anaerobic. It should be the goal of ALL organic tea extraction methods to avoid anaerobic conditions.

1.0 INTRODUCTION TO ORGANIC TEAS

Refer to Table I for a glossary of common terms used herein.

1.1 Background

For centuries, farmers and gardeners have mixed and soaked plant wastes, manures and composts in water, and used the rich decanted brew as a liquid fertilizer, or "organic tea". There is a great deal of testimonial observations that indicate organic teas probably have *some* sort of benefit for growing plants. These observations are supported by scientific research, which shows that organic slurries not only dissolve important nutrients, but, given enough time and oxygen, they can also extracts humic acids, organic nutrients, vital enzymes and beneficial microbes, all of which make for a more vigorous plant.

1.1.1 Commercial Sources of Organic Tea Microbes

Coinciding with the recent interest in organic teas has been the increasing availability of biofungicides and microbial fertilizers on the commercial market. In many ways, these commercial microbial fertilizers and pesticides mimic the effects of organic teas by providing many of the same microbes. They should be considered as possible commercial (=standardized) variables against which organic teas could be tested. They also might be useful as inoculants for making organic teas. Just a very few of the companies offering microbials are listed below, together with a brief description of the various microbe groups offered.

Compost activators and other "microbial inoculants" are sold by many companies. They generally include a variety of microbes from one or more of the following general groups. 1) Nitrogen-fixing, bacteria convert atmospheric nitrogen into ammonia forms available to plants. These include a) non-symbiotic bacteria both aerobic forms like *Azotobacter, Azomonas, Mycobacterium and Azospirillum* and anaerobic types like *Bacillus, Enterobacter, Escherichia and Rhodospirullum* , b) the symbiotic bacteria *Rhizobia* and c) certain cyanobacteria like *Anabaena, Nostoc, Scytonema and Westiella.* 2) Phosphate solubilizing microbes can bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic and fumaric. These acids

TABLE 1
A GLOSSARY FOR ORGANIC TEAS

AEROBIC/ANAEROBIC: Used to describe organisms that utilize oxygen in their metabolism (aerobic or "with air") and those that don't (anaerobic or "without air".)

COMPOST: Organic matter that has been decayed in constructed piles under ideal conditions of carbon, nitrogen air and water. Composting rids organic wastes of salts and toxins and pasteurizes many weeds and diseases. It creates a "stabilized" material that, when added to the soil, can decay rapidly into humus without upsetting the life and properties of the soil. There is no current agreement on what actually constitutes "finished" compost. As a result, both commercial and on-site composts can occur in a variety of states from "fresh" to "well-aged" to "suppressive" depending on the methods and time used in the composting process.

FEEDSTOCK: Organic matter (see below) used in tea extractors.

GREEN MANURES are plants that are grown in the garden and then dug in at season's end. The plant bodies provide fiber that break down in the soil to produce humus. Since most green manures have extensive or deep root systems, they represent one of the few ways that unavailable nutrients leached deep into the subsoil can be made available to plants. Because of this, certain green manures may be an untapped feedstock for organic tea extractors.

HUMUS is the end-product of organic decay; the last stage in the decomposition of organic matter. In spite of decades of study, scientists are still not sure what humus is. It is probably a mixture of a few complex organic compounds that vary according to the type of organic matter decayed and the conditions of decay. Soil humus is traditionally separated from the soil's mineral matrix with NAOH or Na4P207 . The fraction not dispersed by the Na, the chelating action of pyrophosphate or the alkalinity is known as humin. The dispersible material precipitated at acidic pH is called *humic acid.* The material that stays in solution is called *fulvic acids* (62A). Whatever it is, all humus is brown or black, has a fine crumbly texture and smells like fresh sweet earth. It is sponge -like in texture and holds many times its weight in water. Like clay, humus attracts and stores many important plant nutrients, but unlike clay, humus can also act as a powerful chelating agent for the increased availability of micro-nutrients.

ORGANIC MATTER (MATERIALS): The bodies and waste of once-living things. Kitchen scraps, grass clippings, weeds, leaves, sawdust and animal manure are examples of organic materials.

ORGANIC TEA is a liquid extract made by soaking bags of various kinds of organic matter in water to create a liquid rich in the beneficial nutrients, organic compounds and microbes found in the organic materials. T'he liquid tea is than applied in fertigation systems, as a soil drench, or as a foliar spray. Synonym: *Leachate.*

SCUM: A gas / liquid emulsion phase that occurs at high rates of gas production in organic slurries, similar to the "head" on a beer

SLURRY: A mixture/suspension of organic matter in water.

VERMICOMPOSTING makes compost in earthworm cultures. This technique is especially appealing for people who live where bulky compost bins and unsightly heaps are not possible. Moreover, the manure from earthworms, called "castings" is a bit closer to true humus than compost and may have unique properties as an organic tea feedstock..

lower the pH and bring about the dissolution of bound forms of phosphate. P-S microbes include the soil bacteria *Pseudomonas and Bacillus* and the fungi *Aspergillus and Penicillium.*

3) Cellulolytic microbes have the ability to degrade the resistant carbohydrates cellulose and lignin. These include the filamentous fungi (most active in acid soils) *Chaetomium, Trichodenna ,* the bacteria *Cellulomonas, Clostridium* and the actinomycetes *Nocardia and Streptomyces.*

- Mycorrhiza live on plant roots and provide a living link between the plant's feeder roots and the surrounding soil ecology to improve growth rates, resist disease and withstand weather extremes. cor @ from Plant Health Care, Pittsburgh, PA is a combination of endo- and ectomycorrhizal fungal spores, nitrogen-fixing and phosphate solubilizing bacteria, organic nutrients, humic acids and sea kelp extract.

- Residuce from AgriEnergy Resources, Princeton, is a compost tea, combined with liquid humates, fructose, molasses, alfalfa meal, ground chitin and liquefied rock powders with the following advantages: 1) gradually deepens the aerobic zone in the topsoil, 2) builds high quality humus by slowing down oxidation of carbon in favor of microbial digestion into humus, 3) breaks down herbicides faster, 4) reduces allelopathic toxins, 5) improves moisture-holding capacity. The company also sells Soilrite, a liquid extract of dairy manure, chicken manure and compost combined with liquid humates, fish emulsion, cold water seaweed and liquefied rock powders ... essentially a manure extract with supplemental fertilizers. A12plied as a spray at 10- 15 2allons per acre.

9 Actinovate from Natural Industries, Inc. Houston Texas sells a strain of the actinomycete, *Streptomyces lydicus,* (also available in an iron fulvate formulation) which is touted as: "a natural soil and plant inoculant with root zone protection." Developed to promote better seedling growth, enhance overall plant growth and vigor; make micro-nutrients more available; create an environment unfriendly to damaging soil fungi.

Companion or Growth Products, White Plains, N.Y. offers a variety of biofungicides described as "beneficial microbes that crowd out disease-causing pathogens. The microbes attach to root hairs and produce hormones that stimulate root growth.

1.2 Types of Organic-Tea Extraction Systems

In the past, organic tea systems have been described as being either "anaerobic" or "aerobic", depending on the degree of aeration given to the system. As a result of our observations and experiments, we find this distinction to be quite misleading. In the end, all properly designed organic tea systems should be completely aerobic. The real distinction is the degree of aeration given to the system in order to allow it to extract over a protracted time period. We prefer the terms "passive" (a contained or bagged slurry that is simply allowed to soak in water) and "active" or aerated (an organic tea system that receives a boost of oxygen with the use of mechanical mixing, packed columns or forced air.)

In recent years, more attention has been given to teas brewed in aerated systems. Aerated tea devices extend the time of extraction so that a higher quantity and quality of nutrients and microbes can be drawn from the organic feedstock. There are several good references on using and making compost teas from a variety of feedstocks: (3, 5, 13, 20, 22, 28A, 42, 43, 63, 77, 79, 82, 83).

1.2.1 Passive ("Anaerobic") Systems

Passive tea extraction systems are those in which a feedstock is simply left to soak in water. After a few days, passive systems will become anaerobic and, as a result, begin to produce various organic acids such as butyric, proprionic and acetic plus the odors of reduced forms of nitrogen (NH_4) and sulfur H2S)' which, in turn will attract flies. There is some evidence that the by-products of anaerobic decay can actually harm plant roots (James Downer, pers. conim.). Two popular types of static systems include:

- **Soak-in Water Method:** The easiest way to make an organic tea is to add about 2 cups of chopped-up plants (alfalfa and various weeds are popular), animal manure, compost or earthworm castings to each gallon of water, and let it soak for a few days. This is about how long it takes for most of the soluble nutrients to leach out into the water, and for most of the available water oxygen to be consumed by aerobic microbes. When it's done, scoop out the feedstock or drain out the liquid and pour it around your plants as a side-dressing. If you want to spray it on, you may have to strain it through gauze or screen. Follow standard practices for foliar spraying (see Appendix 1)

- **Soak-in Bag Method:** Most tea-makers prefer to put their manures or composts in a bag made of muslin, burlap or other porous material. The "tea bag" is hung in a container of water for one or two days. This produces a much cleaner tea. Use about 1 or 2 cups of organic matter per gallon of water.

1.2.2 Active ("Aerobic") Systems

The trouble with the passive extraction methods is that they can go anaerobic very quickly. When you soak organic materials in water for more than a few days, *aerobic* microbes in the slurry pull all the oxygen out of the water. This turns over the production of the tea to oxygenavoiding (anaerobic) microbes, which produce an inferior tea with fewer available nutrients and organic acids harmful to plant growth. Our research (see following) indicates that there is usually enough dissolved oxygen in clean water so that anaerobic microbes aren't dominant for at least 24-48 hours under most conditions. But after that, the quality of the tea begins to deteriorate. All types of tea systems should be aerobic. The major variable is the length of time that aerobic extraction is allowed to take place.

There is much evidence to indicate that adding air (oxygen) to an organic tea slurry improves the quality of the extracted tea. This seems to be due to the fact that aeration extends the extraction time by several days, which allows the removal of beneficial organic compounds like vitamins, enzymes, organic chelators plus a bevy of beneficial microbes.

1.3 Benefits of OrganicTeas: Research and Observations

Interest in organic teas for use in agriculture and horticulture has grown rapidly during the last decade. The literature (See Bibliography) and web sites (20) are full of experiments, testimonials and observations which suggest that certain liquid extractions of manures or composts (herein called "Organic Teas"), at various stages of decay, can supply plants with at least four major benefits

(5,10,13,42,77,79.): a source of plant nutrients; a source of beneficial organic compounds, an ability to suppress certain plant diseases; a way to build soil structure when applied as a drench.

1.3.1 Provide Inorganic Nutrients and Beneficial Organic Compounds

The types and amount of nutrients in an organic tea depend on the age and kind of material used. The nutrients from fresh manure teas tend to be soluble salts, especially macronutrient (N, P, K, Ca, Mg & **S)** plus micronutrients (e.g., Fe, Zn, Mn and Cu) .

Nutrients from more decomposed feedstocks such as *young or unstable compost* contains some available nutrients not yet fixed in microbial biomass, but they also provide organic nutrients like sugars and amino acids, plus organic chelating agents (humic and fulvic acids) that carry extracted micronutrients (e.g, iron, zinc, manganese and copper) to plants. Since micronutrients are the building blocks of plant enzymes, vitamins and hormones, organic teas can also increase a plant's disease-resistance, vigor and hardiness by providing both micronutrients and the organic chelating agents that make them available. Organic teas also contain long chain carbon molecules which provide carbon and oxygen for soil microbes,- including mycorrhiza. The mycorrhizal hyphae, in turn, greatly extend the root systems of plants which increases their food uptake, respiration, tolerance to weather extremes and, possibly, confer some disease resistance.

1.3.2 Suppress Certain Plant Diseases

It is well known that certain soil microbes have the capacity to suppress many serious plant diseases (1, 19). The disease-suppressive characteristics of organic tea was reported as early as 1973 by Hunt, et al (36A).

Extractions from *well-aged and suppressive composts* (see below) have few soluble nutrients, but they do contain organic chelators and populations of various biofungicidal microbes. These teas have been shown to act as a natural fungicide, i.e., as an inoculum of microorganisms that can compete with and suppress some plant pathogens, especially foliar-fungal diseases.

At the University of Bonn, Germany, Heinrich Weltzien pioneered research in "water extracts of compost." He showed (75A) that organic tea can be used as a foliar spray to inhibit *Phytoph-*

thora on tomatoes and potatoes. Weltzien also showed that the suppressive effect of organic teas are of a living microbial nature. Sterilized or micron filtered tea had little ability to impact pathogens (8 1). He also documented that plants treated with tea appeared healthier and more vigorous than other plants.

Using organic teas or special compost extracts, other researchers and growers have reported modest to major control of several plant diseases with organic teas including: Apple Collar Rot (68), Apple Scab (3); *Botrytis* or Grey Mold (22,69), Downy Mildew (80), *Fusarium (46), Phytophthora* (30,45), Potato Blight (6), Powdery Mildew or *Erysiphe (12), Pythium* (6,8,15,27,33) and *Rhizoctonia,* (18,33). According to these authors, compost teas coat plant surfaces (foliar application) or roots (liquid drench application) with living microorganisms and provides food for beneficial microbes. This helps secure a diverse and healthy food web community where symbiotic bacteria and fungi help provide disease resistance.

In addition, several types of organic feedstocks have produced favorable suppressive results including composts (28, 34, 46, 52, 53, 75, 76, 78, 8 1), municipal and agricultural wastes (74) and various types of lignous materials such as wood wastes and peat moss (4, 15, 18, 27, 30,-32, 35, 43, 49, 59-61, 68, 73).

The principle suppressive microbes in compost teas can suppress diseases in several ways (10):

- They induce resistance against pathogens (pre and posti-infection). - They produce chemical inhibitors as reported for the suppression of *Phytophthora* root rot in media amended with hardwood bark (30, 32). - They inhibit pathogen spore germination - They antagonize and compete with pathogens through the antibiotic effects of parasitism, hyperparastism and nutrient competition. Some microbes, especially bacteria, produce antibiotics which cover the surface of the crop and thus prevent infection by the pathogen. - They extend the root system of plants, and thereby improve nutrient uptake, plus increased food storage and soil respiration.

There is also growing evidence that chemicals called siderophores, pseudobactins and pseudomycins produced by the bacteria *Pseudomonas* spp. exert a powerful suppressive effect on other organisms (47). Kai (43) found that ten proteins from secondary metabolites of plant or microbial origin, effectively suppressed certain pathogenic fungi. In some cases cyanids and antibiotics interact with host plant and create resistance to disease.

It's not always clear which of these effects is most important to a general impression of "disease-suppression" as noted in the literature. Furthermore, not all such experiments have been favorable. Using aerated Luebke compost tea, made in a lab extractor with a vortex nozzle for aeration, Wittig (85) reported that aerobic compost tea was not effective in controlling apple or pear scab, downey mildews, brown fruit rot or peach leaf curl. He generally rejected them as effective controls for: "foliar diseases of fruit trees and grapes." Wittig goes on to note: "Considering that the microorganisms present in compost may be better adapted to a soil environment, perhaps their is greater potential for it's use as a drench in controlling soil-borne pathogens."

In spite of the mixed results, there seems little doubt that certain beneficial microbes can be water-extracted from aerated organic slurries and applied to leaf surfaces (via foliar feeding) and/ or root systems (via drenching or fertigation). These "beneficial" microbes include mycoparasites (7), rhizosphere colonies (14), hyperparasitic fungi (29, 47, 66, 67), epiphytic microbes (65, 86) as well as specific bacteria such as *Pseudomonas (40), Azotobacter* (58), and certain fungi like *Trichoderma and Gliocladium* (36, 62). Apparently disease suppressive microbes that have been extracted from the compost are able to colonize the surface and roots of plant when applied properly (see appendix I). Organic teas simply concentrate these beneficial microbes and allow the grower to apply them in a convenient, concentrated form for nutrients, resistance and disease control (13). <u>In a real sense, organic teas are a concentrated liquid fertilizer and inoculum of beneficial microbes</u>.

It is worth noting that Between 50 and 80 percent of a plant's photosynthates (sugars, complex carbohydrates, animo acids and proteins) are translocated below ground into the root system of most plants (Elaine Ingham, pers. comm.). Of this amount 40 to 60 percent are released by roots as exudates that supply food and create the conditions for colonization of soil nticroorgan-

isms living in the rhizosphere (the microscopic habitat surrounding roots). These organisms, in turn, excrete, die, decay and are consumed by other organisms in the soil's food chain. Through this process of growth, death and decay, the waste and by-products of soil microbes become macro and micro-nutrients for plants. From these facts, one might hypothesize a profound reciprocal (symbiotic) relationship between plants and microbes as yet unexplained.

1.3.3 Help Build Soil Structure

The microorganisms found in organic teas excrete organic gums and resins, that, together with fungal hyphae, bind soil particles into structural aggregates, improving both soil structure and water-holding capacity. Thus, when organic teas are applied as a soil drench, they can promote good soil structure.

2.0 COMPONENTS OF DESIGN

The quality and quantity of nutrients and microbes in an organic tea depends primarily on the nature of the feedstock, the design of the extractor and the ambient environment of the extractor. These variables can serve: 1) as a starting point to outline the basic component variables in the design of *any* organic tea extractor, and 2) as a list of variables to be considered and controlled for in organic tea research experiments. These variables include (but are not limited to) the following:

1) The nature and make-up of the organic matter ("feedstock"),

2) The design of the extractor

- the extractor tank
- the porous extractor vessel / bag
- the type of aeration system

o plumbing for aeration/recirculation - the time of extraction

3) Ambient Environmental Variables

- the temperature of extraction

- the chemical quality of the water used in extraction
- use of supplemental ingredients
- (possibly) the presence or absence of light

2.1 TheVariable Nature of Organic Matter.

Organic teas (i.e., "leachate or "extract") are made by extracting beneficial nutrients and microbes from organic materials ("feedstock") soaking in water ("slurry", "extract" or "leachate"). Like any tea, it's what's in the bag that counts, and the benefits and reliability of an organic tea depend greatly on the quality of the organic matter being extracted. Since organic matter is so variable, both in its chemical make-up and state of decay (type and age), it's not difficult to see why there are so many varied opinions, observations and research results surrounding organic teas.

2.1.1 Variation in Chemical Make-up of Feedstock

Whether it be manure, leaves or compost, organic materials are highly variable in composition. They have a wide range of the main ingredients in any good compost: water, carbon and nitrogen (see Fig. 1, Table 2), not to mention other macro and micro-nutrients, amino acids, sugars etc. For example, the quality of animal manure alone varies tremendously according to: a) the kind and age of animal it comes from, b) how well decayed or how old it is (C / N ratio), and c) the diet of the animal . Plant materials vary primarily due to: a) the kind and age of the plant, b) the nutrients (fertilizers) taken up by the plant, c) the presence of symbiotic nitrogen-fixing microbes, and d) the presence of volatile oils, secondary substances and other plant exudates. Hoitink (32) has shown that the tree species of bark affects the kind of pathogens that are suppressed by the bark in various plant media. For example, compost from hardwood bark suppressed *Rhizoctonia* root rot while a compost prepared from pine bark did not. It is very difficult to find two random piles of heterogeneous fresh organic matter that are statistically similar in chemical make-up.

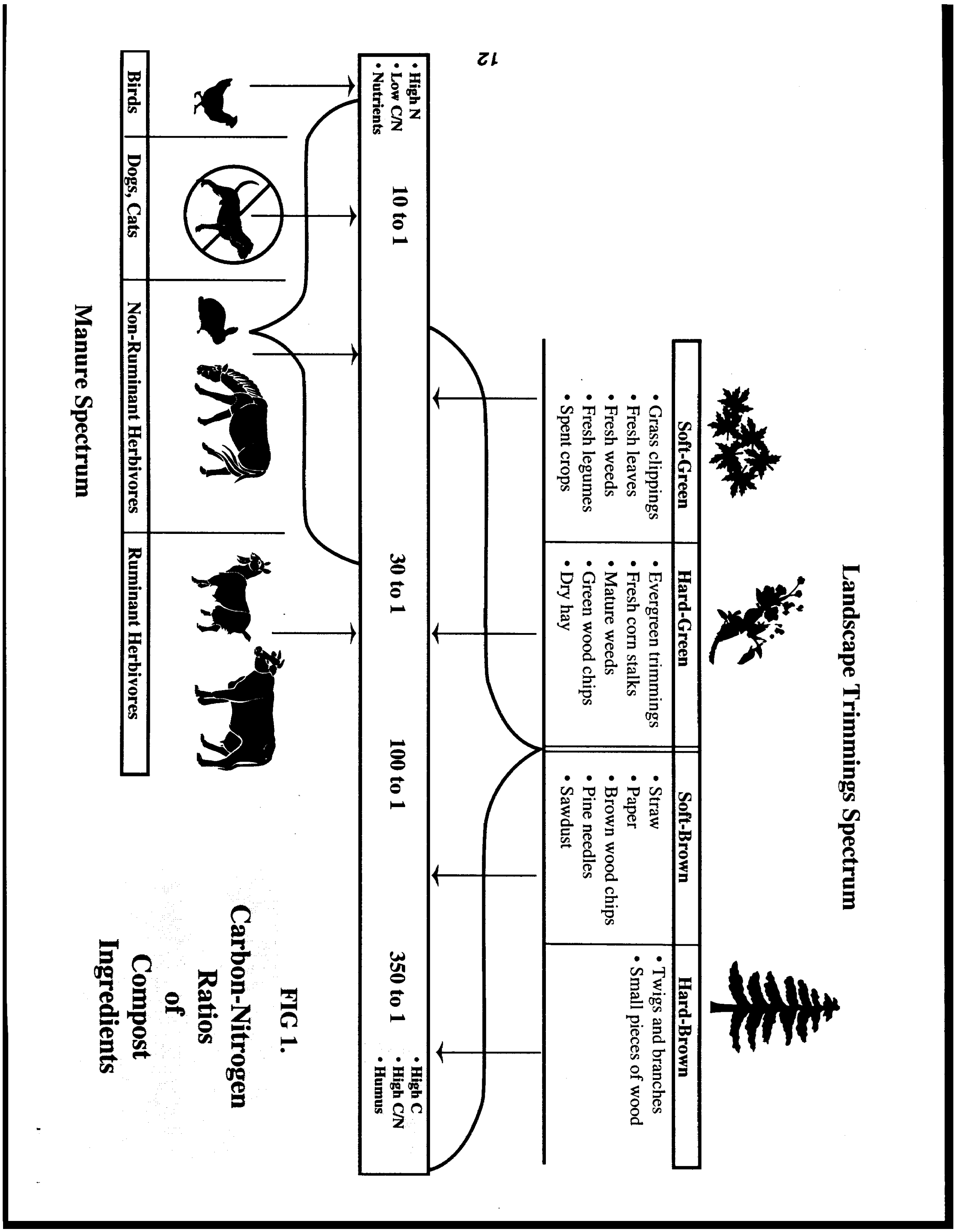


FIG 1.
Carbon-Nitrogen Ratios of Compost Ingredients

TABLE 2

Average Carbon - Nitrogen ratios of various compost materials

TYPE OF WASTES		COMPOSTABLE MATERIALS	C/N
		ACTIVATORS	
ANIMAL WASTES		Urine	1:1
		Blood Meal	4:1
	HIGH N	Dry Fish Scraps	5:1
PLANT MEALS	LOW C	Soybean Meal	5:1
		Cottonseed Meal	5:1
MANURES			
		Chicken Manure	10:1
ANIMAL MANURES		Pig Manure	15:1
		Horse Manure, fresh	15:1
		Sheep, Goat Manure	20:1
		Horse manure with bedding	
		Cow Manure	25:1
GREEN PLANT MATERIALS		**SOFT GREEN**	
		Alfalfa Hay	12:1
		Grass Clippings	15:1
		Seaweed	19:1
		Kitchen Scraps	15-20:1
	BALANCED	Green Weeds	20:1
	C/N	Spent vegetables	20:1
		Fresh fall leaves	30:1
		HARD GREEN	
		Mature weeds	25:1
		Leafy Prunings	35:1
		Leafy wood chips	40:1
		Dry hay or Weeds	40:1
		Stalks of Corn, Sunflowers	50:1
		SOFT BROWN	
BROWN PLANT MATERIALS		Dry Leaves	60:1
		Cornstalks	60:1
		Straw	70:1
		Newspaper	200:1
		Cardboard	250:1
	LOW N	Brown wood chips	300:1
	HIGH C	Sawdust	500:1
		HARD BROWN	
		Twigs and branches	400:1
		Wood	500:1

2.1.3 Variation in States of Organic Decay

All organic matter eventually decays. How quickly and completely it breaks down depends on the interplay of four ingredients: carbon, nitrogen, air and water. These elements have to be in just the right proportions for organic matter to decay efficiently into humus. If one of these elements is absent or overabundant, decay to humus slows down or stops all together. It follows other pathways to decay, and produces different product (Table 3). For example, if we took three samples of *fresh* organic matter from the same homogeneous pile and decayed one pile in a compost bin, the second one in an anaerobic digester and the third under water, we would no longer have the same type of organic matter. The very nature of the decay would have changed that. This is one reason why a poorly mixed compost pile produces such variable compost. Some of it has probably undergone all three types of decay and produced three types of compost ... not all suitable for making good humus ... or organic tea. In general, the more energy one puts into the compost process, the less chance there is for either anaerobic or protracted decay. (Fig. 2).

2.1.4 Variation in the length of aerobic decay.

Even under ideal conditions, the chemical and biological properties of humification (cornposting) will vary according to how long it has been decaying. Younger compost is closer to the original raw materials than well-aged compost. There is some evidence (35) that as compost ages, it converts sugars and carbohydrates, which many disease organisms prefer as food, into starches that beneficial (predatory) microbes prefer. In other words, there is a succession of microbes as humification proceeds such that younger composts provide different extracted resources than older composts (Fig. 3).

With these ideas in mind, we can describe the value of three general types of feedstocks whose benefits are, at least in part, determined by their age of decay.

- Manure: Teas made from animal manures are richer in nutrients than compost teas because manures have not undergone the aerobic process of decay ... humification... that immobilizes

TABLE 3: THE FOUR PATHS OF ORGANIC DECAY

A good way to appreciate the ways that organic matter decays in nature is to take a hike. Imagine you're in a woodland area, and you come across a large pond. Plants at the edge of the pond are matted down into a wet, compacted mushy texture, much like a pile of kitchen garbage or fresh grass clippings. The carbon, nitrogen and water are adequate for fast decay, but there is no oxygen. The result is a smelly incomplete decay or **putrefaction.** Decay can take from months to years.

Looking out at the center of the pond you notice tiny bubbles at the surface. This is methane gas produced by putrefaction of plants at the bottom of the pond. Because it is under water the putrefying sediment is called "peat." **Peats** are very acidic and are not completely decayed. Look at peat moss closely and you will see bits and pieces of the original moss plants. Peat moss is used to lighten and acidify soil mixes, but it is not humus. If we want to see nature's humus you have to look at situations where there is plenty of air, and only moderate water.

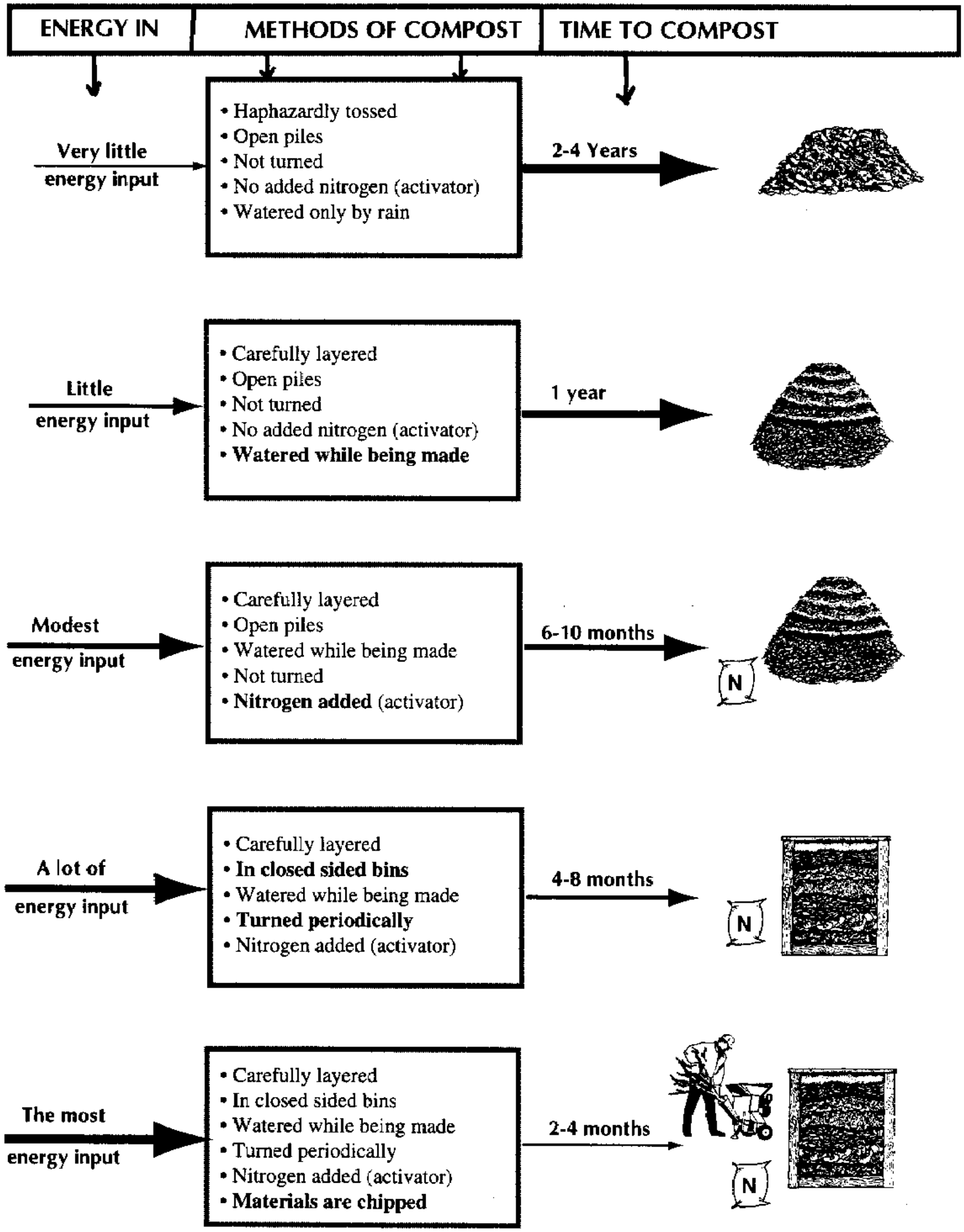
As you walk about the woods, you notice a fallen tree trunk rotting on the forest floor. It has taken decades to decay this far, and decades from now the once proud trunk will disappear into crumbs of humus. This **dry decay** is very slow because the tree trunk is high in carbon and low in water and nitrogen, which have to be brought in by rainwater or animal droppings. Humus happens, but it is very slow.

Humus is made more quickly in places with a proper balance of carbon and nitrogen, lots of air and moist (not wet) conditions. Nature shows us two examples. The first is leaf litter. If you scoop some up from the forest floor, you'll notice that at the surface you can see rotting leaves and twigs. Below this is a dark, porous layer with not trace of leaf or twig. This is forest humus and the process is **humifaction.** The decay is complete, and the smell is sweet and musty. Leaves are full of carbon, nitrogen and water, and they fall so as to leave air spaces.

We can also find conditions for complete rapid decay in the topsoils of grasslands. The fibrous and deep roots of grasses produce a rich airy soil that allows dead plants to decay quickly in the well-drained sod. This is why grasslands are so productive; their topsoils are high in humus. Leaf litter is nature's compost pile and grasslands are nature's green manures.

TYPE OF DECAY	RATE OF DECAY	C/N	AIR WATER	BY-PRODUCTS	EXAMPLES NATURAL	 RESIDENTIAL
Humifaction	Weeks to months	Balanced	Normal moist	C02 Humus	Leaf lifter Grassland soil	Compost piles Worm Cultures
Putrifaction	Months to years	High N	Low high	Methane Sludges	Fresh manure Compacted, fresh plants	Wet garbage Grass clipping piles Septic Systems
Peat Decay	Years to decades	High C	Low very high	Methane, sulfides Peats	Estuaries, bogs, lakes	Bottom of garden ponds
Dry Decay	Decades to generations	Very high C	Normal dry	C02, water Humus	Fallen trees Piles of branches	Piles of twigs and branches

Fig, 2 TIME AND ENERGY IN COMPOSTING



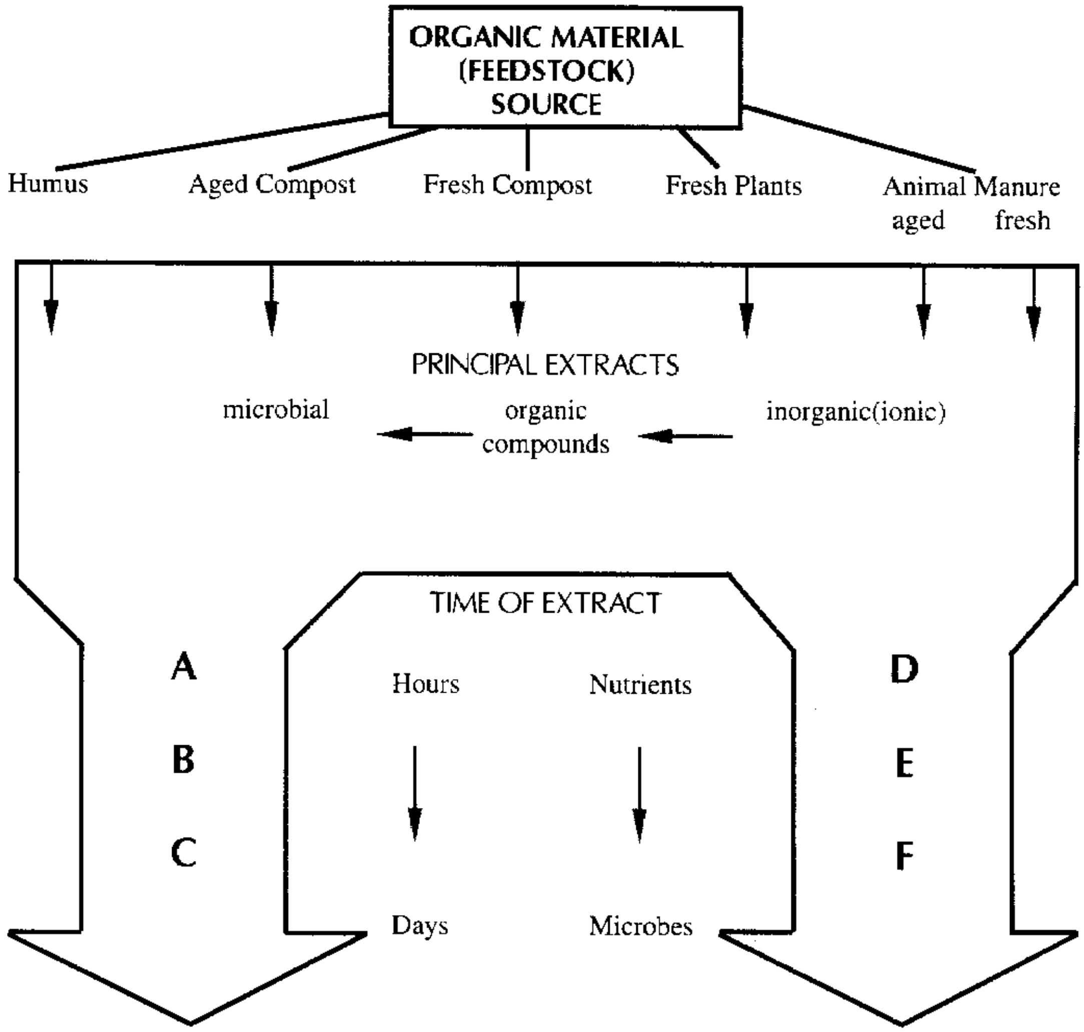


Fig. 3. The quality of organic tea is primarily related to three variables:
1) the source and nature of the feedstock
2) the state of decay of the feedstock, and
3) the length of time of (aerobic) extraction

Fig 4. Mod #2 double barrel aerobic tea extractor.

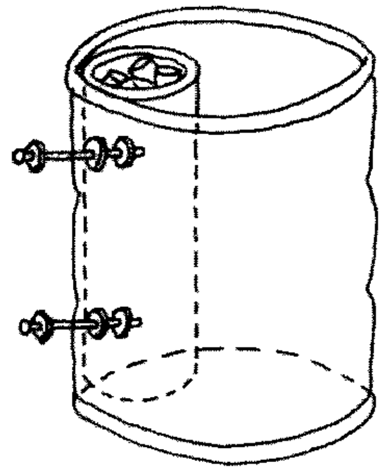


Fig 6. Packed column (4 inch PVC) bolted to top of tank. A gravity-fed aeration system.

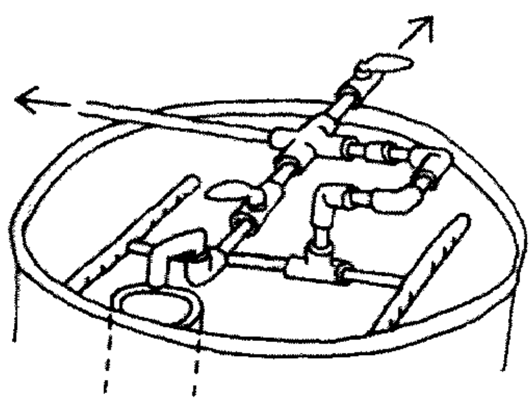


Fig 5. Spray head assembly.

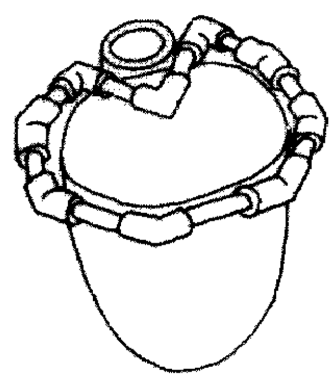


Fig 7. Porous bag assembly.

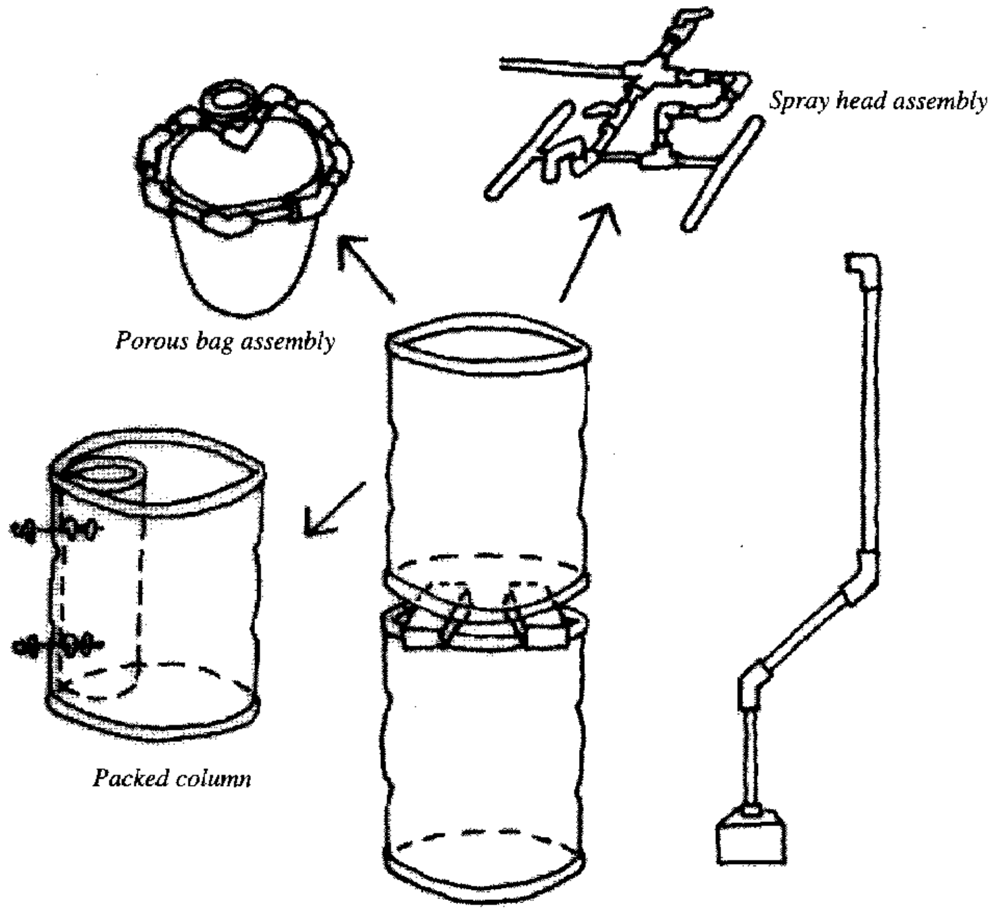


Fig 8. Mod #3 Aerobic tea extractor; components of design

and volatilizes many of the fresh nutrients. Properly made manure teas are good source of nitrogen, phosphorous, potassium and trace elements. Only a few manures are really suitable for making organic teas. These include horse, cow and goat manures. Horse manure yields more nutrients, cow manures provides more humic acids (see Fig. 1.). Avoid the manure of chickens, turkeys, cats, dogs and pigs. They can harbor pathogens and are difficult to handle.

- Fresh Composts : Teas made from fresh compost (aged less than 6 months after cool down) contain fewer nutrients than manures, but they do provide humic acids, which can chelate micronutrients and help plants to resist some diseases.
- Aged and Suppressive Composts: It is well known that certain types of soils can harbor populations of beneficial microbes that suppress plant diseases (2, 38, 51, 87). Likewise, there is growing evidence that well-aged compost can also nurture disease-suppressing microbes (17, 78, 83). Such composts are said to be "suppressive" because they may suppress certain plant diseases, much like suppressive soils.

Aerobic teas made from *aged or suppressive* composts contain more beneficial microbes, especially if they have been well aerated and allowed to brew for several days. Suppressive compost teas can be sprayed on leaves where the beneficial microbes can colonize leaf surfaces and help protect the plant against some leaf and soil-borne diseases. In a real sense, suppressive teas are a concentrated liquid inoculum of beneficial microbes. Less is known about the antibiotic effects of suppressive organic teas applied as a drench.

The debate as to what really constitutes true or "finished" compost (for commercial or research purposes) has not been solved in the research community. When is compost "done"? We have examined several commercial composts only to be disappointed by the fact that most of them were not a finished product. They smelled of ammonia and/or sulfur (rather than a musty soil), they were variable in color and texture and they lacked the presence of late succession soil meso- and macro-fauna so common to finished compost. It's economically difficult to cover rented or productive land with compost for extended periods, so it's tempting to sell it as fresh as possible. But we still have no concrete definition of "finished" compost. One thing we can say, however. During composting, heterogeneous materials are converted into a homogeneous material by an ecological succession of different microbes ... each stage of decay producing a unique array of microbes and nutrients, and a different type of organic material from fresh to suppressive. This is why manure is a different feedstock than young compost, which is different than old compost, which is very different than *really* old compost. The extractions effects of the state and age of decay for organic tea feedstocks is shown in Table. 4.

Table 4: The make-up of an organic tea depends on the quality of the feedstock and the period of extraction. Below are the hypothetically possible results of a double variable experiment.

	1st 48 hours	> 48 hours
ORGANIC MATERIAL	**Passive**	**Aerated**
Fresh Manure	many nutrients	few nutrients
Fresh (8 mos) Compost	some humates few nutrients	some nutrients some humates
Aged (suppressive) Compost	few nutrients many carbos some humates some sugars	few nutrients some sugars some amino acids some enzymes some microbes many humates many carbos

1 = as soluble ions or chelates

2.2 The Design of the Extractor

2.2.1 The Extractor Tank

(see pg. 29)

2.2.2 The Porous Extractor Bag or Vessel

(see pg. 31)

2.2.3 The Type of Aeration System

There are several ways to aerate tea systems each with its own unique mechanical and plumbing (aeration and recirculation) sub-systems.

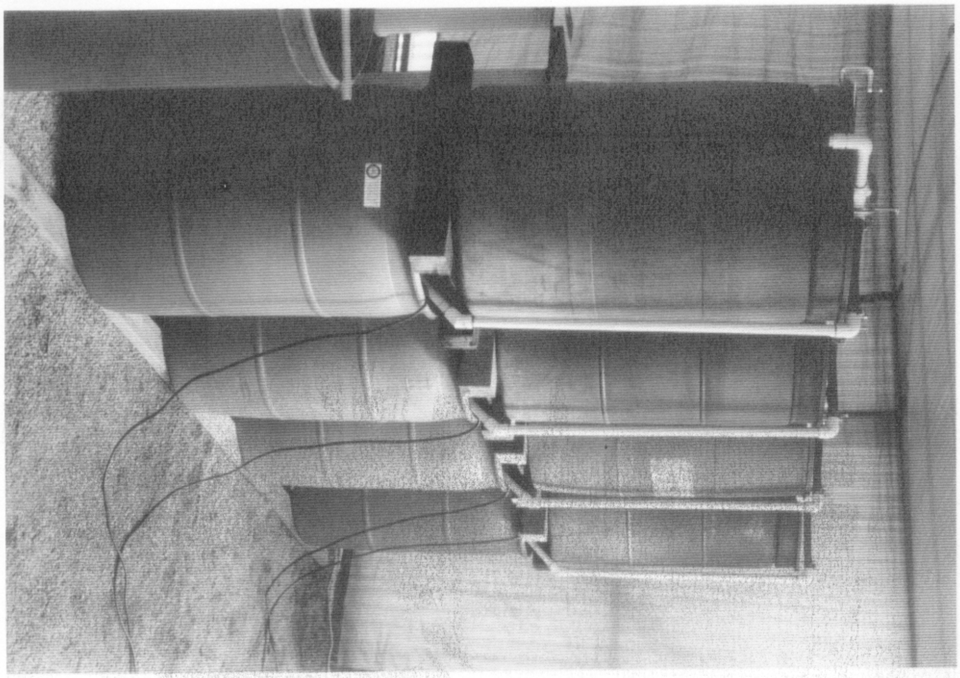


Fig. 9. Eight appartuses(i) active-passive tea extractors. Experimental units

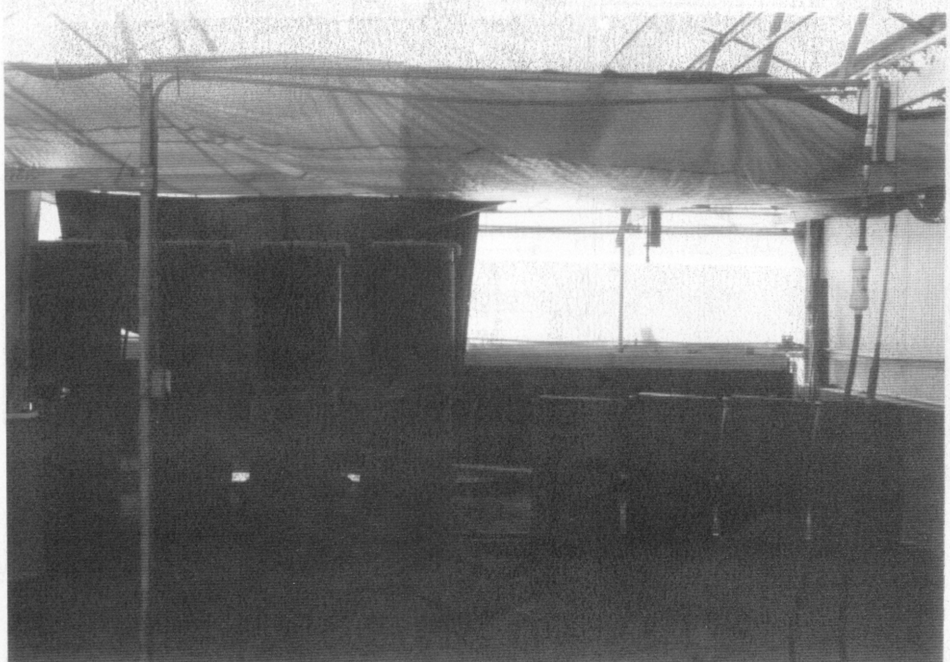
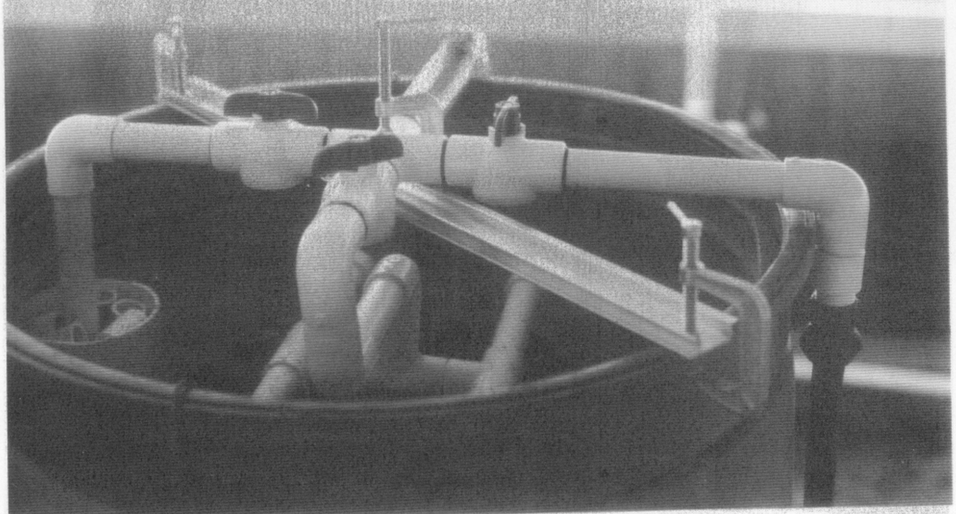


Fig. 10. Spray head assemblies. Experimental units



-Stirring and Bobbing: Frequent stirring or bobbing of the tea bag in the water helps to get air in the slurry.

- Waterfall over tea bag; You can make high quality aerobic teas by placing your compost or manure in a fine wire or plastic mesh bag, and suspending it about one foot above a water container. Then spray water over the tea bag using sprayers or perforated pipe. Turn the water on and off several times a day or put it on a timer. Brew for up to a week or so. Adventurous tea makers can use a sump pump and container drums to continuously recirculate water over the bags (see pg. 30).

* **Aquarium air bubbler:**
* **Packed Columns:** (see pg. *29)*
* **Efficient Aerobic Microbes:**

From personal communications it's apparent that some researchers are considering the use of hiahlv efficient aerobic microbes as a biological means of aeration, one that would fluctuate in more synchrony with the natural microbial populations of the tea.

2.3 Ambient Environmental Variables

Independent of the actual system design are some environmental variables that also effect the quality of the tea. These include: 1) the chemistry of the water, 2) the temperature of the extraction, 3) the time of extraction, and 4) any supplements to the feedstock.

2.3.1 Chemical Quality of the Water

The chemical properties of the water being used can strongly effect the quality of tea produced. Acid and alkaline water with little buffering capacity can keep certain microbes from flourishing. Excess salts can do the same thing. When possible try to use filtered, spring or rain water, which will produce a richer tea.

2.3.2 The temperature of extraction

All of the organic tea apparatuses at Cabrillo College were maintained outside and under a shade structure. It was clear that the production rates of tea varied greatly with the swings in daily and seasonal temperatures. For Cabrillo College, ambient temperatures varied from daytime highs in the upper 70's (August-November) to nighttime lows in the lower 30's (DecemberFebruary). Our observations seemed to indicate that below 45-50 OF. extraction was noticeably slowed down. Since most nutrients tend to be more soluble in warmer water, and because microbial respiration rates are proportional to ambient temperature, heating the slurry or keeping the extractors in heated spaces might have some merit in the future.

2.3.3 The Time of Extraction

We have mentioned elsewhere that the time of tea extraction strongly effects the quality and composition of organic teas. According to Cantisano (13) "Tea for nutrient and humic acid extraction are ready in 1-2 days ... some disease suppression is noted from these young teas; more time is required for maximum disease suppressive teas."

2.3.4 Supplements to Feedstock

Several researchers and practitioners have recommended the addition of concentrated supplemental nutrients to increase microbial activity in organic teas. These include sugars, unsulfured molasses (at I tablespoon of molasses per 5 gallons of water), rock fertilizers, kelp and fish products and barley malt.

We would only add the possibility of adding commercial microbial cultures (see pg. 2) to jump start microbial activity in organic teas.

3.0 EXPERIMENTS AND OBSERVATIONS AT CABRILLO COLLEGE 1995-1998.

3.1 HistoryofTheCabrilloTeaApparatusProject(CTAP)

3.1.1 Mod. #1 (Appendix I)

In the fall of 1995, students of the Horticulture 2 class (Soil Science and Management) began researching the literature and networking with specialists about the potentials for using organic teas (both compost and manure) as a foliar spray to increase the vigor of plants. Responses from literature searches and experts were favorable, and the Cabrillo Tea Apparatus Project (CTAP) began. The first design consisted of ten gallons of compost wrapped in 50% shade cloth and placed in ten gallon planting container. It was held in place over a fifty-five gallon barrel by a pair of two-by fours. A submersible pump, fitted with a garden hose recirculated water from the bottom of the barrel to the top of the five gallon container.

This first model (Mod #I) had many problems. Compost particles from the top container were constantly clogging the pump causing the pump to shut off. This would cause the tea and the compost to produce a foul smell, indicative of an anaerobic condition. This system also lost a lot of tea in the process of recirculation. The hose at the top produced a spray which kept some of the tea from going back through the top container. We also found that the hose head made a narrow steam of tea that did not saturate the entire container of compost evenly. Much of the time on the first project was spent trying to get the system to complete one full run of five days without shutting down. Literature searches and communications with others studying the use and microbial populations of compost teas increased our interest and carried the project to the next semester. The apparatus was modified to solve the problems evident with Mod 1.

3.1.2 Mod. #2 (Appendix I)

For Mod #2 we replaced the top ten gallon container with a fifty-five gallon barrel to match the one on the bottom (Fig. 4). The recirculation hose was replaced with rigid I" PVC pipe. At the top, the PVC pipe extended to the middle of the barrel. A two-way hose adapter replaced the hose end from Mod 1, better dispersing the tea over the compost. Window screen was placed between the two barrels to screen compost particles. We suspended the compost in the top barrel by using a large piece of shade cloth which extended out of the barrel and was wrapped over the lip. It was secured to the barrel using large hose clamps fitted end to end. An aeration system was added to the bottom barrel using an aquarium air pump and air stones.

Mod 2 had its problems. The force of the tea from the spray head pushed too much compost though the shade cloth causing it to build up on the screen between the two barrels. Eventually, it kept the tea from falling to the second barrel, so that it spilt out on the ground. The level of tea dropped in the bottom barrel until the float switch shut off the pump. The fine particles of compost that made it though the screen settled at the bottom and produce an anaerobic sludge. The aeration system proved to be ineffective and got in the way. Changing the compost after a production cycle was time consuming , because we had to take the system apart just to change the compost.

We did however get the system to run through a five day production cycle and the development of the apparatus coincided with a germination study using the tea and *pythium* infested soil. Continued conversations with researchers and interviews with farmers making their own teas in the Salinas and Central valleys continued the development of the CTA.

In the spring of 1997, the compost tea project became a special studies course for the horticulture program and incorporated students from the entomology class. The system was modified again to solve the problems of the previous system. Mod 3 had an entirely redesigned spray head. The spray head diverted into three lines at the top barrel (Fig. 5). One line diverted the tea to a line out, controlled by a ball valve. This allowed us to pump out the bottom barrel for extracted tea and foliar spray our row crop growth study. A second line diverted the tea, via another ball valve, to a new aeration system called a packed column. The third way lead to the spray head. It consisted of two 14" long PVC pipes with six 1/4" slits cut halfway though the bottom side, which sprayed tea onto the compost These pipes were set about 8" apart and were directly over the suspended compost. This line also had a ball valve which allowed us to control the flow of the tea over the compost.

The "Packed Column", our new aeration system, consisted of a 4" diameter 2 1/2' PVC pipe that was bolted to the inside of the top barrel (Fig. 6). This column was filled with I" pieces of PVC pipe, which aerated the tea as it fell down the column.

The screening system between the two barrels was also changed. We constructed two 1' x l' screens that stacked on top of each other with about a one inch gap between them. They were set upon C-clamps nailed into the 4x4 spacers directly under the flow of tea. This allowed us to clean one screen while still screening the tea. We also began de-chlorinating our water with a filter purchased from Peaceful Valley Farm Supply and began adding sulfured molasses and azomite rock powder to boost populations of bacteria and fungi.

Mod 3 enabled us to run production cycles without problems. By controlling the flow of tea and dispersing it evenly over the compost we had no problems with compost building up on the screens and flowing out onto the ground. Also, diverting some of the tea to the Packed Column reduced the pressure of the spray head. Our largest problem was in changing the compost between runs. We still had to disassemble most of the apparatus to remove the shade cloth and empty the compost. Our next step was to have the organic tea tested for microbial populations at 24 and 48 hour run times to establish the effectiveness of the apparatus.

Our current model of the CTA has solved the problem of the shade cloth compost container. A ring has been made of PVC parts with shade cloth zip-tied to it (Fig. 7). This drops into the top barrel and hooks to the side using two 10" S-hooks. The design allows it to fit around the packed column and lifts out after disconnecting the spray head from the pump assembly(Fig. 8.) Funding from OFRF allowed us to construct four identical apparatuses whose consistent production of tea was a component of protocol for further research experimentation.

The overall design of the Cabrillo organic tea extractor is meant to be simple, inexpensive, and use parts easily available to a farmer, nursery worker or researcher. What follows are instructions for building the apparatus in a step by step manner, completing assembly of six individual components, which make up the entire apparatus. These components are (Fig. 9):

- The Containers
- The Packed Column
- The Pump Assembly
- The Spray Head
- The Feedstock Container
- Miscellaneous Parts

3.2 Construction Details of the Cabrillo College Organic Tea Apparatus

The order of assembly is important since completion of one component leads to the placement and sizing of the next. A complete list of parts and tools provided is in **Appendix II.** Cost analysis of the CTA is available in **Appendix III.**

3.2.1 The Containers (Figs. 4 & 10)

- Cut the tops off of the barrels. Drill a 1/2" hole on the top of the barrel on the inside of the lip. Insert the scroll saw and cut around the circumference of the barrel to remove the top. . - On the bottom of the top barrel, draw a 10"x 7" using a permanent marker. Using the scroll saw, follow your markings to remove the diamond.

- Use a utility knife to cut a piece of the inner tube (one layer thick) so that it extends I" beyond the edges of the diamond. Measure and cut a slit lengthwise in the middle of the piece of inner tube 3 and 1/2" in length. Sand the inside edges of the diamond as well as the edges of the inner tube with the 80 grit sand paper. Apply the waterproof silicone to the sanded areas and glue the inner tube to the *inside* of the barrel. This creates a funnel which prevents the tea from leaking out the sides of the bottom of the barrel. It also reduces the splash and loss of tea as it falls between the barrels.

3.2.2 The Packed Column (Fig. 8)

- Place the pipe inside the top barrel. Bring the top of the pipe 2" from the top of the barrel and hold it there. On the outside of the barrel measure down 5" from the top of the barrel. Take the drill with the 1/4" bit and drill though the barrel and the pipe. - Remove the pipe and measure down 2' from the first 1/4" hole on the barrel. Drill a second hole though the barrel.

- Measure 2' down from the first hole on the pipe and drill a second 1/4" hole.
- Take the 5"x 5" piece of chicken wire and cover the bottom end of the 4" pipe. Fold the chicken wire around the outside of the pipe and slide the 4 and 1/2" threaded hose clamp

over the wire. Secure the wire to the pipe by threading down the clamp. This serves to keep the 1" PVC pieces inside the packed column.

- Attach the Packed column to the inside of the barrel using the bolts, washers and wingnuts. Use the PVC pipe cutters to 1" pieces of I" PVC pipe. Fill the column with the PVC pieces to within I" of the top.

3.2.3 The Pump Assembly

- Check the size of your submersible pump line out. Make sure you have the right fitting to adjust the pipe size to 1/2".
- Cut a 1'8" piece of PVC pipe. Glue the line out fitting to the pipe and attach it to the PUMP.
- Place the assembled pieces inside the bottom barrel.
- Cut a 1'10" piece of PVC pipe. Glue a 1/2" 45 degree PVC piece at each end of the pipe. Make the angles of the 45's opposite each other, one facing down to the pump and the other facing up towards the top barrel. Glue into place on the assembled pieces inside the barrel. - Place the two 2' lengths of 4x4" spacers on the top of the bottom barrel. Place the top barrel on the spacers.
- Adjust the pump assembly so that the top of it extends out the back of the bottom barrel. Measure the distance from the top of the pump assembly to the top of the top barrel and cut a piece of PVC pipe to size. Glue into pump assembly.
- Glue a 3" piece of 1/2" PVC pipe into a 90 degree piece. Slip a 1/2" ID (inside diameter) piece of clear poly hose over the 1/2" PVC piece and secure with a 1/2" hose clamp. This will connect to the spray head and serve as a visible flow check. - Glue the 1/2" 90 degree PVC piece on the top end of the pump assembly.' **3.2.4 The Spray Head (Figs. 5 & 11)**
- Individually assemble the top, connector, and bottom pieces of the spray head and then glue

the three pieces together. The connector piece should be lined up directly underneath the line above it, so that it is running back towards the cross-piece. Attach the bottom piece to the connector piece so that the spray lines parallel the connector piece. - Check the spray head assembly for fit in the top barrel. Connect the spray head to the pump assembly and secure using a 1/2" hose clamp. Stabilize the spray head by placing a yardstick across the top of the barrel and under the top piece of the spray head. **3.2.5 The Feedstock Container (Fig. 7)**

* Cut a 4' diameter circle of shade cloth.

* Assemble feedstock container ring. Refer to diagram for feedstock container ring assembly

* Place shade cloth inside ring so that there is a I" to 2" margin around the outside.

* Use zip-ties every 1 and 1/2" to fasten the shade cloth around the ring

* Use two 10" S-hooks (bought or easily made from 14 gauge wire) to hang inside the top barrel. Note the inverted side of the ring should fit around the packed column.

3.2.6 Miscellaneous Parts

The Barrel Spacers

- On the two 2' lengths of 4x4, measure in from each side 9". Center two C-clamps at the 9" marks and nail into place. Leave a I" gap between the C-clamps. These will serve to hold two screens in place.

The Barrel Spacer Screens

- Assemble two 12"xl2" screens using a window screen kit purchased from a hardware store or from existing materials. These serve to screen compost particles from the tea and keep compost from settling in the bottom barrel. With two screens, one can be cleaned easily.

3.3 Experimental Results

3.3.1 Introduction

Our problem from the start was that there is no consistent experimental protocol for testing the design and effectiveness of organic tea extractors. Because of this, we shifted our original

experimental purpose (with the permission of the OFRF staff), and focused on: 1) the design of a simple, experimental organic tea extractor, and 2) a preliminary experimental protocol that is useful to both researchers and growers alike. To wit:

- Test the consistency of design and operation of the Cabrillo Organic Tea Apparatus in search of a prototype, inexpensive extractor that will produce expected microbial populations consistently.
- Establish an experimental protocol for future projects and experiments that will further define what is being produced in aerobically made organic teas.
- Sample, test for, and document any short-term differences between aerobic and anaerobic teas given the COTA design and the nature of the compost feedstock.

3.3.2 Methods

The experiment phase of the COTA project began in May of 1998. The experiment was set up and performed in an empty greenhouse at the Cabrillo College Horticulture Facility so that we could control the external temperature and environment for all of the individual tea apparatus' (Fig. 10). *Four aerobic* tea apparatus' were built following the plans of the current design model. In addition, four *anaerobic* barrels were designed to be used along side the aerobic apparatus'. These anaerobic barrels consisted of the same type of plastic, fifty-five gallon barrels used for the aerobic apparatus'. Shade cloth sacks were sewn to hold the same amount of compost as the aerobic apparatus'. These sacks were suspended in the middle of the barrels using a length of line and a metal bar.

At the same time the apparatus' were being built at Cabrillo, we located a consistent supply of well-produced compost. The compost itself was taken from piles at Route One Farms, Ocean St. Ext. location. Two fifty-five gallon barrels were filled by shovel, taking shovelfuls of compost from all sides of the piles and at different heights and depths of the piles. These barrels were then taken to the Cabrillo College project site. Grover Environmental Products in Modesto, CA produced this compost (see Appendix IV for analysis). As compost production and mandatory waste reduction is becoming big business for California, Grover has developed a large-scale operation that produces quality , near-finished compost. Their source for compost comes from vegetable produce waste from supermarkets, city greenwaste collection programs and their own landscaping business. These greenwastes are sorted into different piles for carbon and nitrogen sources. These piles are then screened and mulched and replied to be used in their row production of compost. Their row composting process was patterned after the Lubke method (find Lubke ref) and has been altered to suit their own production emphasis. They have designed their own row turning equipment that measures moisture content and adds water as needed while turning rows. Their rows are monitored daily for 0_{2}, ammonia, pH, and temperature, which does not exceed 145 OF.. In addition every 3000 yards of compost is checked for heavy metal content. Their ammonia content is regulated by the state waste management board. They are registered with California Compost Quality Council, which is made up of composting businesses working to ensure the quality and safety of compost. The compost that Grover produces has its own set of standards and is available for review (App. IV). Given the standards for production that Grover has established for its compost business we were confident that they could supply a consistent source of high quality, near-finished compost for our project; they also have ties and reputation with farmers who know their product and might also be looking at composts teas as part of their production management.

The experiment proceeded as follows. All barrels were filled with fifty gallons of water using a garden dechlorinator to reduce chlorine content. Five gallons of compost was added to every apparatus, in shadecloth bags for the anaerobic barrels (#5-8) and in the feedstock container for the aerobic barrels (#1-4). At the same time samples of compost were collected from the feedstock containers of barrels 1-4 and one sample from the pile of compost. These were sent to BBC Labs for compost analysis to serve as a comparison to the tea tests sent at 24 and 48 hours. At 4:00pm on June 2111 the four aerobic barrels were turned on and the shadecloth bags of compost were put in the anaerobic barrels. Data collection began immediately. Every two hours, excluding the hours from 12am to 8am, we measured oxygen (O2 and pH, electrical conductivity (EC), and temperature. 02 measurements were taken with a portable 02 meter to measure the differences in 0 2 levels between the aerobic and anaerobic production methods. These measurements were taken within the barrels at a middle depth for the aerobic barrels and at a surface depth and bottom depth in the anaerobic barrels. EC, pH and temperature were taken with portable meters as well (App. V). Samples were extracted from each barrel and tested in a cup. These measurements were taken to establish any trends during production and add to compiling data of these factors that are of concern to anyone applying teas to their product. At the 24 hour mark, tea samples were taken from all eight of the barrels and sent to BBC Labs (as per their instructions) for their compost tea analysis. After the samples were taken, 32 oz of sulfured molasses and 32 oz of azomite rockpowder were added to barrels 1-4. These supplements were added as a food source for potential microbes within the tea to see if there would be any population increase in the groups tested for by BBC labs in the 48-hour sample. Also at the 24 hour mark, at the suggestion of Marc Buchanan, the anaerobic barrels were mixed vigorously for I minute and done so every four hours following up to the 48 hour mark. This was done to document any trends in the difference between the active and passive approaches to anaerobic tea production. All measurements were continued until the 48 hour mark, at which point tea samples were taken from barrels 1-4 and sent to BBC labs for compost tea analysis. At this point the physical experiment of the COTA project was completed.

Time	**Project 1 (24 hrs)**	**Project 2 (48 hrs)**
Passive	1-4 (a-d)	not done
Active	4-8 (e-h) -	1-4* (i-e)

* After 24 hrs, addition of molasses and azomite

Table 5. Experimental Design of Cabrillo Organic Tea Project

3.3.3 Results

See Cabrillo Dataset, BBC dataset, and graphs produced by Marc Buchanan (App. V - VIII)

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-There were minor differences in bio-plate count between the sub-samples of compost taken from the same batch (Appendix VIII).

- There was no significant difference in 0_2 between passive and active treatments over 24 hour period. (Appendix IV). Our experiments confirm those of others that so-called anaerobic tea systems ... those in which organic stock is simply soaked in water.. are actually aerobic for the first 48 hours or so of soaking. In other words, "aerobic" systems are merely extending the time of useful extraction by putting MORE oxygen into the system.

-There was no significant difference in bio plate counts between passive and active treatments during the first 24 hours, but there is during the first 48 hours in aerated systems (Appendix VIII).

FUTURE STUDIIES

Given the results of the 0_2 levels in COTA and the passive barrels, a test using water only should be performed using both systems to test again the 0_2 levels present in both systems. Alternatives to increase aeration should also be looked into. For instance, the aeration systems used by municipal water treatment plants that provide 0_2 for microbial breakdown of waste products.

- A test involving microbial supplements of molasses and azomite in both passive and aerated systems with no supplements, from hour 0 to 48 hours.

-24 hr run time vs. 3 to 4 day run time with bioassay testing.

-Standard allelopathy study. Taken from S. Gleissman, *Bioassay forAllelopathic Potential.* From Field and Laboratory Investigations in Agroecology. 1998, Ann Arbor Press, pg. 139-155. Adapted to a germination study / disease suppression study using compost tea.

- If suppressive microbes tend to be found more in older teas (several days) than younger ones (1-2 days), is it possible that the organic matter being extracted is, itself, undergoing decomposition in a complex aerobic/anaerobic environment within the slurry, i.e., maybe the extra time needed to extract better microbes is really just more time to give the feedstock time enough to decompose to the appropriate microbial substrate.

CRITIQUE OF COTA

COTA was field tested by farmers at Route One Farms, Santa Cruz, CA. Their critiques are as follows.

- The capacity of the machine was too small for field use. Given this limitation they adopted it for use on greenhouse seedlings. However, they currently have modified the bottom barrel by enlarging it to a container that can hold up to 250 gallons and are planning to use teas in the field at a 50% dilution.

- The top barrel is extremely heavy after producing tea due to saturated compost. Removing and replacing the compost takes more than one person.

- The feedstock container was too difficult to use given its placement inside the top barrel. They replaced it with a plastic container the goes all the way to the top of the barrel and although still heavy, easier to deal with.

- Screening and sprayhead clogging is a problem with fine sized compost. Molino Creek Farm was also interested in a tea apparatus. The need for a consistent power source for the submersible pump was a problem for them. They suggested an alternative power source for COTA such as photovoltaic cells which could handle the relatively low power demand.

4.0 SUGGESTIONS FOR A FIELD EXPERIMENT PROTOCOL

Having reviewed over 100 papers on organic teas, we are unable to reach any basic conclusion as to the value or efficacy of organic teas. The problem, as we see it, is that there is no standard protocol for organic tea experiments. A protocol is important because of three major sources of variation: 1) the organic feedstock, 2) the method of extraction, and 3) the time interval of extraction. The idea here is to find ways to extract from various types of organic materials (fresh or aged manures; fresh, aged or suppressive composts), their micronutrients, microbes, enzymes, hormones, by soaking them in solutions (passive) or extracting them with water flow (aerated) *to achieve consistent results in the quality of the tea.*

-The most difficult variable to control is the feedstock, whether it is fresh manure or suppressive compost. A consistent source of feedstock should be found and sub-samples taken from *the same batch.* If possible, inorganic nutrient and bioassay tests should be done on pilot subsamples to establish the degree of variation within the feedstock (Appendix IV).

- The method of extraction is a function of the type of extractor used, and the conditions under which the experiment takes place. Replications should be assigned to extractors of similar design and aeration units. Since multiple replications are so important to a welldesigned experiment, it is important to find a well functioning, yet inexpensive extractor design such as the one described in this report. Experimenters should also control for the following environmental variables (pg. IO, I 1): 1) the temperature of extraction, 2) the chemical quality of the water used in extraction, 3) the use of supplemental ingredients, and 4) the amount of ambient light.

- An efficient organic tea experiment should focus on a minimum number of variables at a time because of the inherent variability of the testing situation.

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