Chapter 1 - Compost Quality

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It is a simple fact: you cannot have high quality compost tea without high quality compost. In other words, if you want to promote plant growth with compost tea the extract must be derived from compost that also promotes plant growth. Compost quality is determined by starting materials (feedstocks), as well as the management of moisture, temperature, other production factors and storage conditions. All of these factors influence the rate of biological decomposition and ultimately determine final compost quality. Publications on compost production are available from several sources elsewhere (Rynk and Richard, 2001; Sheldon et al., 2005). This chapter is intended to improve the compost tea practitioners awareness of indicators that are most commonly used to evaluate compost quality.

Maturity

Maturity is an important concept that is closely related to the quality of compost. Simply put, mature compost has decomposed enough to promote plant growth. Objective indicators of maturity have been established and are discussed below. Most of these indicators require special equipment or analysis fee, and it takes time for results to be received.

Experienced producers and users of compost often evaluate maturity using subjective indicators such as color, smell, and feel (Kuo et al. 2004; Sullivan and Miller, 2001). Dark brown, earthy smelling, moist, and finely divided composts that lack sour or ammonia off-odors are expected to be of adequate maturity to promote plant growth. However, more quantitative measures are required to better enable end-users to determine the optimal rate and frequency of compost application.

C:N Ratio The ratio of carbon to nitrogen in compost is probably the best known objective indicator of compost quality. Optimal C:N range is considered 10-20:1 since composts within this range are unlikely to immobilize, or "rob" plant available nitrogen. Typically, composts with C:N above 25:1 are unacceptable for use in cropping systems. It is important to note that C:N ratios are not adequate to use as the sole determinant of compost maturity. However, C:N ratios are extremely useful in prescreening compost for acceptable maturity. Compost that have C:N $< 25:1$ should be further evaluated for other indicators of compost maturity.

Stability A common measure of compost maturity is stability or the potential for compost to further decompose. The most common measure of compost stability are self heating tests where the maximum rise in temperature of moist compost are measured over a 5-10 day period. Excessive heating (>20^{o}C increase in 10 days) indicates unstable compost (Briton, 2000).

Respiration or carbon dioxide evolution from moistened compost is also used as an indicator of stability. Respiration and self heating are both indicators of biological activity. Although biological activity is

Figure 1.1 Compost quality is often described in terms of maturity; Mature compost promotes plant growth, while immature compost retards it. Phytotocicity resulting from immature compost may be due to high C:N, the presence of toxic compounds or other factors. In the photo above eggplant seedlings are growing in an immature thermophilic compost (left) and mature vermicompost (right). *Photo: Ted Radovich*

considered desirable in composts, unstable compost that rapidly consumes oxygen can result in anaerobic conditions after bagging, resulting in off-odors and the production of phytotoxic compounds. Unstable composts are also likely to be low in plant available nutrients.

Plant available nitrogen Nitrate and ammonium are important indicators of compost maturity (Briton, 2000; Sullivan and Miller, 2001). Nitrate concentration is recommended to be at least 100 ppm for mature compost. Some sources recommend that nitrate and other plant available nitrogen should not exceed 300 ppm when compost is being used as a substrate in growing medium. However, composts with nitrate concentrations of greater than 600-2000 ppm are associated with the best plant growth in greenhouse and field trials in Hawaii (Pant, 2011). Ammonium should be less than 1000 ppm and the ratio of ammonium to nitrate in the compost should be less than 1:1.

Other measures of quality Other measures of maturity include EC (<2.0 mmo), pH (6.0-7.5). Compost quality is also indicated by the presence or absence of contaminants (Walker, 2001). Potential major contaminants include human pathogens, physical contaminants such as plastics, weed seeds, heavy metals, and pesticide residues. Maintaining high temperatures for a period of time during the composting process has been the primary approach towards minimizing contaminants particularly human pathogens. Screening is also recommended which generating and removes the bulk of physical contaminants.

Not all compost is created equal

Vermicompost -

Vermicompost is generated by worms and associated microorganisms. Vermicompost quality will vary depending on many factors including worm species, raw material used, and the age of the compost. Vermicomposts are generally of finer structure, contain more nutrients, and have higher microbial activity than other types of composts. High levels of nutrient levels and plant growth regulators make vermicompost ideal for compost tea production.

"Handcrafted" or "Artisan" thermophilic

Careful monitoring of the compost temperature and conditions can maximize plant nutrients and biotic properties. Artisan thermophilic compost is appropriate for compost tea, but the quality can vary significantly depending on the feedstock and handling.

Commercial large scale

Large scale operations serve the purpose of processing large amounts of waste material. Generally, this type of compost is best used as a soil amendment, rather than for compost tea, because of low levels of mineral nutrients and biological activity.

(Photo: Nguyen Hue)

Why is verimicompost so great?

Vermicompost quality will vary depending on many factors including worm species, raw materials used, and age of the compost. Vermicomposts are generally of finer structure, contain more nutrients, and have higher microbial activity than other types of compost. Worms facilitate two sets of processes: gut associated processes and cast associated processes (Dominguez 2004). In gut associated processes, several things occur: the fractionation and homogenization of materials, the addition of sugars, the modification of microbial populations and the addition of mucus and excretory compounds (e.g. urea and ammonia). In cast associated processes, high mesophilic microbial activity further decomposes and mineralizes the material under protected (i.e. covered, moist, dark) conditions. Both processes contribute to the relatively high maturity indicators and positive plant growth response observed in vermicompost compared to other types of composts.

The University of Hawaii compared select quality characteristics of thermocomposts and vermicomposts from various sources (Table 1.1). One benefit of vermicomposts is the relatively large amount of plant available nitrogen that they contain in the form of nitrate (NO_3^-). This is partly due to the enclosed nature of vermicomposting that reduces losses of NO_3^- and other nutrients. Allowing vermicompost to cure (stored in aerated container that conserves moisture) after harvesting for 3-4 months can also dramatically increase the NO_3^- content (Figure 1.2). Note the high CV levels indicate a great deal of variation in mineral nitrogen from sample to sample.

Figure 1.2: NO_3^- increases exponentially over time in cured vermicompost, after removal of worms. Data points in figure below are means of three analyses; bars are standard error of the means. "Curing" refers to the finishing of compost after the active composting process. Compost stored under warm conditions in plastic bags or bins to retain moisture will continue a prolonged mesophilic stage that results in bulid up mineral nutrients and other compounds. These composts have been found to be most effective for use in compost tea (Chapter 3).

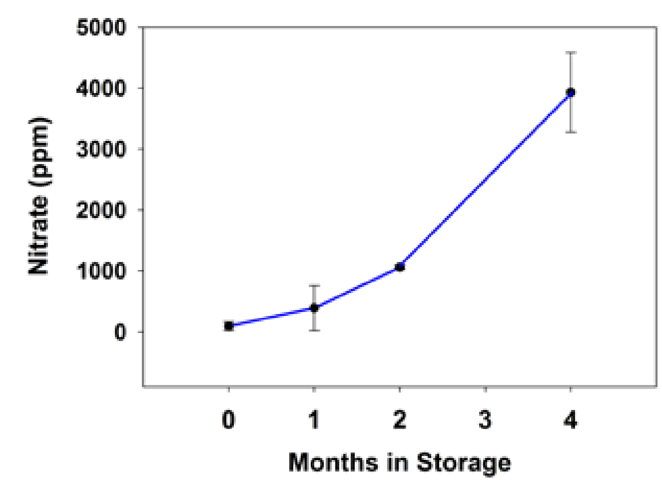

Table 1.1 Select nutrients found in vermicompost and thermal compost available in Hawaii. Analysis were conducted on 157 compost samples 2006-2011.

Method	Feedstocks		# of Samples		N	C:N	P	K	--------PPM------ NO_3-N	NH_4-N
Vermicompost	Foodwaste	Mean	42		2.11%	12:1	0.79%	1.47%	1672.2	141
		Range			0.89-4.59%	5.1-25.1	0.06-2.06%	0.06-4.83%	267-2986	2-969
		CV †			39%	27%	70%	98%	93%	164%
	Manure	Mean	59		1.67%	14:1	3.04%	0.55%	1988.88	185
		Range			1.29-2.25%	10:1-18:1	0.40-6.03%	0.08-2.39%	316-4824	1-2063
		CV			15%	15%	53%	111%	72%	255%
Thermal	Greenwastes	Mean	28		1.28%	21:1	0.45%	0.77%	634	21
		Range			0.67-2.72%	8:1-40:1	0.14-0.92%	0.21-1.12%	35-1913	0-175
		CV			37%	42%	47%	30%	80%	369%
	Manure & mortalities	Mean	28		1.77%	19:1	1.69%	1.68%	3834	243
	Mortalities	Range			0.61-3.01%	10:1-26:1	0.21-3.78%	0.48-3.13%	60-8625	26-1813
		CV			42%	47%	70%	58%	79%	163%

† **CV** - Coefficient of variation is an indicator of the variation within the compost samples for that nutrient.

N - nitrogen, **C:N** - Carbon to nitrogen (see page 8,) **P** - phosphorus ,**K** - potassium, **NO_3-N** - nitrate N, **NH_4-N** - amonium N

OK for Organics?

Compost Use - NOP Rule 205.203(c)) for compost use states that compost is compliant for use in certified organic systems if three conditions are met:

1. The compost is made from only allowed feedstock materials.
2. The compost undergoes an increase in temperature to at least 131°F (55°C) and remains there for a minimum of 3 days.
3. The compost pile is mixed or managed to ensure that all of the feedstock heats to the minimum temperature for the minimum time.

If composting in windrows, Plant and animal materials are composted through a process that establishes an initial C:N ratio of between 25:1 and 40:1 and maintains a temperature of between 131°F and 170°F for 15 days, during which period the composting materials must be turned a minimum of five times. Compost that contains no animal materials as feedstock may be used without restriction provided that it contains no prohibited or restricted-use plant materials. Acceptable feedstocks include, but are not limited to, by-products of agricultural commodities processing, and source-separated yard debris or "clean green." Compost that contains more than $1x10^3$ (1,000) MPN fecal coliform per gram of compost sampled or more than 3 MPN Salmonella per 4 grams of compost sampled will result in a reclassification as 'manure'. Composts that contains sewage sludge, synthetically fortified compost starter, glossy paper, and materials containing colored ink are prohibited.

Frequently Asked Question:

How much time between foliar applications and harvest?

This an area still in development. At the time of printing, there are no explicit restrictions in the NOP guidance or NOSB recommendations on pre-harvest interval as long as the compost is produced according to the NOP guidelines described above and NO MICROBIAL FOODS ARE USED. If microbial foods are used, the resulting tea must be tested for pathogens (e.g. E. Coli O157 and Salmonella). If the tea is found to be clean then future testing is not required if the brewing process and compost are not changed.

OMRI's current interpretation of compost tea is much more conservative. They consider all compost teas to be raw manure regardless of compost type. That means 90-120 days pre-harvest interval (see facing page).

We suggest avoiding manure based inputs and retesting for pathogens each time protocols or inputs are changed. If your tea is non-manure based and pathogen free, a pre-harvest interval may not be needed, but some consumers may not like the idea of spraying with microbes (even good ones) right before harvest.

Tea Use - The NOP is vague on the use of compost tea. In its 2006 recommendation, the National Organic Standards Board (NOSB) defined tea as a water extract of compost produced to transfer microbial biomass, fine particulate organic matter, and soluble chemical components into an aqueous phase, intending to maintain or increase the living, beneficial microorganisms extracted from the compost. The final NOSB recommendation stated "Recommendation: Compost teas if used in contact with crops less than 120 days before harvest must be made from high quality compost described above and not prepared with addition of supplemental nutrients such as sugars, molasses or other readily available (soluble) carbon sources."

The NOSB recommendations also state:

1. Compost teas must be made with potable water.
2. Equipment used to prepare compost tea must be sanitized before use with a sanitizing agent as defined by 21 CFR 178.1010, using allowed materials found on the National List.
3. Compost tea must be made with compliant compost or vermicompost, using the NOSB recommendation for compost and vermicompost mentioned above, and as defined in section 205.203 (c) (2) of the NOP rule.
4. Compost tea made without compost tea additives can be applied without restriction. Compost tea made with compost tea additives can be applied without restriction if the compost tea production system (same compost batch, additives, and equipment) has been pre-tested to produce compost hat meets the EPA recommended recreational water quality guidelines for a bacterial indicator of fecal contamination (US EPA, 2000).

The Organic Materials Review Institute's classification of compost tea as raw manure is extremely conservative and seemimgly incongruent with NOSB and NOP guidance:

> *"Compost tea used as a fertilizer or soil amendment is subject to the same restrictions as raw, uncomposted manure. It may only be (i) applied to land used for a crop not intended for human consumption; (ii) incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or (iii) incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles. Compost tea made on the farm may be used to suppress the spread of disease organisms. Compost tea sold for disease suppression must comply with all pesticide regulations. "* (OMRI, 2011)