Compost:
Matching Performance Needs With Product Characteristics

California Environmental Protection Agency
Integrated Waste Management Board

Introduction

Compost is becoming an increasingly popular soil amendment with growers, landscapers, and other end users. Compost consists of organic matter (such as leaves, landscape trimmings, food scraps, or woody debris) that has undergone varying degrees of decomposition.

In California, commercial composters are required to meet specific regulatory requirements on the compost process itself that protect health and safety. However, because no state or national standards exist for rating the quality of compost products, you must perform your own quality assessment. In addition to a visual inspection, you may want to assess other compost characteristics to ensure that you're getting a product that meets your specific needs within the price range that you're willing to pay.

Before shopping for compost, determine your reasons for using compost. Once you've determined the performance requirements (e.g., for seed germination), look for a compost with appropriate characteristics. The following information is designed to help you assess compost products.

The first section discusses compost stability and maturity. The second section is organized by compost performance requirements and, under each requirement, information regarding individual compost characteristics.

Assessing Compost Stability and Maturity

Stability and maturity are terms often used to characterize compost, yet opinions about what these terms mean vary widely. The term "stable" typically refers to a compost that is not undergoing rapid decomposition and whose nutrients are slowly released into the soil. Unstable compost, because it is still decomposing, can use or "tie up" nitrogen from the soil, although it still may be useful in certain situations. For example, conventional growers may apply unstable compost to increase soil organic matter; if they also are applying an appropriate amount fertilizer, they may not be concerned about a small amount of nitrogen immobilization from unstable compost. Most uses of compost, though, require a stable product that prevents nutrients from being tied up.

The term "mature" typically refers to the degree of completeness of the composting process. In mature compost, raw feedstocks have sufficiently decomposed for 60 to 90 days under controlled moisture and aeration conditions and cured for another 30 days to result in a stable product that is not phytotoxic to plants. Immature compost may contain one or more growth-inhibiting compounds (e.g., short-chain organic acids that are phytotoxic to seedlings), weed seeds, or other undesirable characteristics.

Compost stability and maturity are difficult to assess by simple sight or smell. In general, though, mature compost will not contain recognizable feedstock material, should smell like rich soil, and should not smell foul or ammonia-like.

Indicators of Compost Stability

Temperature of the Composting Pile. In general, in moderate climates, if the temperature of the composting pile is more than 15°F (8°C) higher than the ambient air, the compost may be unstable.

Respiration Rate. The rate of oxygen utilization and/or carbon dioxide release may be used to assess respiration rate, a measure of biological activity. The Solvita test, available from Woods End Research Laboratory, is a quick test for respiration rate. However, composts that are cold or dry or that have a high salinity content may not respire even though they are unstable.

Length of Composting Process. In general, compost from an aerobic windrow should be processed for a minimum of 60 to 90 days, although even after this time the compost may still be unstable. Most compost should be actively processed 90 to 120 days to be considered stable. This additional processing time results in compost that is sometimes referred to as being "cured." Some experts believe that compost should be cured for six months before use.

Carbon:Nitrogen (C:N) ratio. The C:N ratio usually decreases during the composting process and consequently is sometimes used to indicate compost stability. However, for this ratio to be used meaningfully, you need to know relative C:N ratios at the beginning and end of the composting process. Ideally, C:N should be approximately 30:1 at the beginning. If the C:N ratio is low at the beginning (e.g., around 10:1 or 15:1), then a low C:N at the end may not indicate stability. Assuming the beginning C:N is approximately 30:1, the C:N of stable compost at the end of the process will be between 10:1 and 20:1, with the most stable composts falling in the lower end of this range. A final C:N above 20:1 may indicate a compost that will not readily release nitrogen, while a final C:N above 30:1 may indicate a compost that will inhibit nitrogen mineralization and tie up nitrogen from the soil.

Indicators of Compost Maturity

CCQC Maturity Index. Maturity cannot be described by a single property. Some laboratories assign a maturity index to compost based upon germination rate, root tissue growth, and other factors. The California Compost Quality Council (CCQC) developed a numerical *Maturity Index* that uses standard laboratory tests to rate compost maturity. To qualify as "mature" or "very mature," a compost must have a C:N ratio of less than or equal to 25 (see discussion of C:N in "Indicators of Compost Stability" above) and pass two additional tests performed concurrently on the same sample, one test from "Group A" and one from "Group B."

- Group A tests, which indirectly measure the degree of organic matter decomposition, include carbon dioxide release or respiration; oxygen demand; and Dewar self-heating test.
- Group B tests, which measure chemical characteristics of the product (some of which can be toxic to plants) include ammonium nitrate ratio; ammonia concentration; volatile organic acids concentration; and plant bioassays.

CCQC publications (see "Additional Resources" below) describe how to apply the index and interpret test results to determine whether a compost is very mature, mature, or immature, and provide general guidelines on best uses of composts based on the Maturity Index rating.

Seed Germination. Whether or not the index is used, growers concerned about phytotoxicity may perform a simple seed germination test themselves using radish seeds or the seeds that they will be planting. The following Web site includes guidelines for conducting germination tests: www.compostinfo.com/tutorial/MaturityTests.htm. Many laboratories also will perform seed germination tests.

Matching Performance Needs With Product Characteristics

Source of available nutrients

Feedstock Type (Compost Ingredients The nutrients in the feedstock will determine the available nutrients in the final product. Compost made from manures and biosolids is frequently higher in

	nitrogen (N) than that made primarily from yard trimmings or wood.
Salinity	Not a significant factor.
Effect of Composting Method	The anaerobic compost process (exposed to little or no oxygen) generates significant amounts of ammonia (NH_3) that are released into the atmosphere, leaving less nitrogen in the compost product. Compost that is produced through an aerobic process (exposed to adequate amounts of oxygen) generates less volatile ammonia.
Stability/Maturity	Stable and mature compost contains a variety of available macronutrients, such as carbon (C), nitrogen (N), phosphorus (P) and potassium (K). Compost also contains micronutrients, such as copper (Cu), iron (Fe) and zinc (Zn). Unstable compost can immobilize nitrogen (N) and make it unavailable for plant use. See comments on the last page for information on assessing stability/maturity.
Nutrients	Most compost suppliers will give an analysis of major nutrient content in compost. However, not all of the nutrients are available for plant use. Typical mineralization (plant availability) rates are 10 percent to 15 percent for N and 30 percent for P for the first year. Approximately 85 percent of K is available during the first year. To calculate available nutrients, multiply the mineralization rate by the total amount of nutrient in the compost. Mineralization rates may vary by feedstock. Although significant N may not be readily available for fast-growing crops, its slow release contributes to soil nutrient levels over time.
pH	The pH of the growing medium plays a large role in the availability of plant nutrients. In general, the pH of the compost should be greater than 5. However, pH of the soil should be taken into account.

Source of beneficial microorganisms

Feedstock Type (Compost Ingredients)	Some research suggests that carbon-rich feedstocks produce a compost with a higher fungal content and that nitrogen-rich feedstocks produce a compost with a higher bacterial content. More diverse feedstock may result in a more diverse population of microorganisms. Carbon-rich feedstocks include leaves and yard trimmings. Nitrogen-rich feedstocks include manures.
Salinity	Not a significant factor.
Effect of Composting Method	Aerobically composted material is more likely to contain beneficial microorganisms than anaerobically digested or processed materials. Large compost piles may be more difficult to keep aerobic. However, large piles may be kept aerobic through frequent turning. Refer to the “Compost Quality Standards” publication listed on the last page for information on desirable microbiological test results.

Stability/Maturity	In general, beneficial microorganisms are found in mature compost. See comments on the last page for information on assessing maturity.
Nutrients	Not a significant factor.
pH	Alkaline (pH greater than 7) soils tend to be dominated by bacteria. Acidic (pH less than 7) soils tend to be dominated by fungi.

Appropriate for seed germination and/or transplants

Feedstock Type (Compost Ingredients)	Compost made from animal manure may not be appropriate for seed germination and transplants since it is frequently higher in salinity than compost made from yard trimmings and woody debris. Salinity should be assessed through lab analysis.
Salinity	.75–3 dS/m (deci-Siemens/meter or millimhos/centimeter) is best for seedlings and young, tender plants. This should be the salinity of the final growing medium after compost has been applied and blended.
Effect of Composting Method	Aerobically composted material is most appropriate for seed germination and/or transplants. Compost that is intentionally, or unintentionally, anaerobically composted may contain ammonia and volatile organic acids that are considered toxic to plants. A smell of ammonia can indicate an immature and/or anaerobically composted material.
Stability/Maturity	Stable and mature compost in combination with fertile soil or potting mix can be safely used for seed germination and/or transplants. Immature composts usually contain more growth-inhibiting substances that can be toxic to plants. A germination test is recommended prior to compost use. See comments on the last page for information on assessing compost stability/maturity.
Nutrients	Too much N can sometimes kill seedlings. In most cases, compost should be blended with soil prior to use for new growth. A standard blend for nursery use is 15 percent to 25 percent compost mixed with a standard wood residual.
pH	pH less than 5 is likely to be immature and contain growth-inhibiting substances that can be toxic to plants. Best results are likely with compost that is neutral to alkaline (pH greater than or equal to 7).

Will not introduce viable weed seeds or pathogens

Feedstock Type (Compost Ingredients)	The type of feedstock composted will determine the likelihood and the type of noxious weed seeds and pathogens that may be present prior to composting. E. coli and salmonella are most prevalent in manure and biosolid feedstock. Seeds would be most likely in yard trimming feedstock.
Salinity	Not a significant factor.

Effect of Composting Method	Most weed seeds and pathogens are killed by high temperatures during the thermophilic stage of the composting process. However, some weed seeds are resistant to high temperature. Pursuant to State regulations (Title 14, California Code of Regulations, Section 17868.3), compost must be exposed to high temperatures for specified periods of time to kill weeds seeds and pathogens: • Windrow method (elongated piles of compostable material that is turned on a periodic basis): 131^{o}F (55^{o}C) for 15 days with a minimum of 5 turnings. • In-vessel method (compostable material that is enclosed in a container): 131^{o}F (55^{o}C) for 3 days Aerated static pile method (compostable material exposed to an air distribution system that either blows or draws air through the material): 131^{o}F (55^{o}C) for 3 days.
Stability/Maturity	Stable compost is unlikely to contain viable weed seed or plant pathogens
Nutrients	Not a significant factor.
pH	Not a significant factor.

Will not introduce contaminants

Feedstock Type (Compost Ingredients)	Contaminants in the compost product are dependent upon the type and cleanliness of the feedstock used and the level of grinding and screening. Visual inspection may identify some contaminants, such as plastic bags. Trace Elements: Biosolids may be significantly higher in trace elements, including heavy metals, than yard trimmings. However, heavy metals in compost produced by a permitted facility cannot exceed U.S. EPA Part 503 maximum levels. Glass, Plastic, and Metal Objects: Yard trimmings vary in the degree of inert contamination. Plastic sheeting from trash bags is common. However, most of these contaminants can be removed by the processor through adequate screening.
Salinity	Not a significant factor.
Effect of Composting Method	Not a significant factor.
Stability/Maturity	Not a significant factor.
Nutrients	Not a significant factor.
pH	Not a significant factor.

Enhances water holding capacity, soil structure, organic matter, drainage, and nutrient holding capacity of soil

Feedstock Type (Compost Ingredients)	Most compost is high in organic matter. Higher organic matter content in the compost will increase water-holding capacity. It also improves soil structure in both clay and sandy soils. Because it can break up clay soils, organic matter can help improve drainage. Organic matter also increases cation exchange capacity (CEC). Soils with a high CEC hold onto nutrients and reduce leaching to groundwater. Soil added to the compost may decrease total organic matter.
Salinity	Not a significant factor.
Effect of Composting Method	Compost that is ground and/or screened to a smaller particle size (less than ½ inch) may improve cation exchange capacity (CEC).
Stability/Maturity	Not a significant factor.
Nutrients	Not a significant factor.
pH	An acidic compost (pH less than 7) can have a higher cation exchange capacity (CEC) than an alkaline compost. At high rates of application, the CEC from compost may be a significant proportion of the total CEC in the soil, especially on sandy substrates.

Does not significantly increase soil salinity

Feedstock Type (Compost Ingredients)	The composition of the feedstock will determine the salinity of the final compost. The composting process actually concentrates salts so the finished product is higher in salinity than that the starting material. Compost made from animal manure may not be appropriate in specific situations since it is frequently higher in salinity than compost made primarily from yard trimmings or woody debris.
Salinity	Certain crops may not tolerate high-salinity compost. For most established crops, electrical conductivity (used to measure salinity) of the growing medium (after compost has been applied and blended) should not exceed 5 dS/m.
Effect of Composting Method	Not a significant factor.
Stability/Maturity	Not a significant factor.
Nutrients	Not a significant factor.
pH	Not a significant factor.

Additional Resources

Internet Sites

- **Integrated Waste Management Board:** www.ciwmb.ca.gov/Organics (916) 341-6620.
- **California Compost Quality Council:** www.ccqc.org/ (530) 265-4560.
- **U.S. Composting Council:** www.compostingcouncil.org/ (440) 989-2748.
- *** Woods End Research Laboratory:** www.woodsend.org/ (800) 451-0337.
- *** BBC Laboratories, Inc.:** www.bbc-labs.com/ (602) 967-5931.
- *** Soil Foodweb, Inc.:** www.soilfoodweb.com/ (541) 752-5066.

** Reference does not imply endorsement by the Integrated Waste Management Board*

Publications

- ***How Do I Know That Compost Is Mature? An Introduction to the CCQC Maturity Index.*** California Compost Quality Council. Available at www.ccqc.org/.
- ***Compost Quality Standards & Guidelines.*** William F. Brinton, Woods End Research Laboratory, December 2000. Available at www.cfe.cornell.edu/wmi/Compost/.
- ***How Agricultural End Users Can Assess Compost Quality.*** Jean VanderGheynst, UC Davis. Available from the IWMB at (916) 341-6620.
- ***Field Guide to Compost Use.*** U.S. Composting Council, (440) 989-2748.
- ***Interpretation Guides to Compost Stability and Compost Maturity.*** BBC Laboratories, Inc., (602) 967-5931.
- ***Compost Quality Standards.*** Organic Ag Advisors and BBC Laboratories, Inc. Available from the IWMB at (916) 341-6620.
- ***Test Methods for the Examination of Compost and Composting.*** U.S. Composting Council, (440) 989-2748.
- ***Compost Production and Utilization: A Growers' Guide.*** Mark Van Horn, UC Division of Agriculture and Natural Resources, (510) 642-2431.
- ***Compost—A Guide for Evaluating and Using Compost Materials as Soil Amendments.*** William Darlington, Soil and Plant Laboratories, Inc. Available from the IWMB at (916) 341-6620.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web site at www.ciwmb.ca.gov/.

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