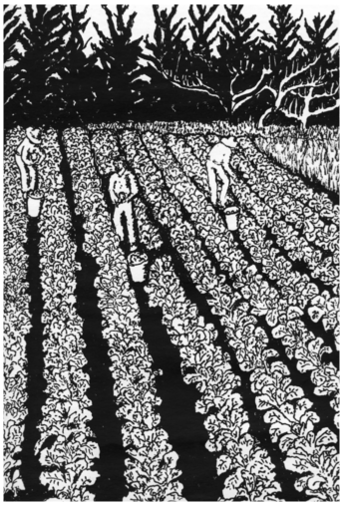
Forrest Cook

News & Notes of the UCSC Farm & Garden

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Making Quality Compost

– by Orin Martin

Compost, the process and the product, is yet another example of harnessing biology to assist us in promoting healthy soil that in turn grows quality crops. Compost, green manures (cover crops), and sound soil cultivation practices are the three primary drivers of any sustainable growing system. Indeed, we are "biological farmers/gardeners," not merely organic growers. We also find ourselves enamored of the Buckminster Fuller phrase, "Work smart, not hard," or at least, "Work smart, not *so* hard."

Composting is about the decomposition and transformation of heterogeneous organic wastes (basically anything that was once alive) into a homogeneous, stable end product—organic matter/humus, or as we call it, compost. Quality compost is a uniform product black in color, crumbly in texture, sweet smelling, slightly greasy to the touch and a powerful reservoir of plant nutrients that are released slowly over time via further biological activity. You can think of compost as "black gold" for the garden or farm—arguably the most precious substance on the planet.

No self-respecting definition of compost would be complete without the phrase "under controlled conditions." Yeah, "compost happens," as the bumper sticker states, but you may actually be able to make compost better (and certainly quicker) than nature can.

Benefits

Among the attributes of compost are –

• It immobilizes nutrients in the bodies of microorganisms. This keeps nutrients, especially nitrogen, from leaching out of the pile. When the finished compost is applied to the soil, nutrients are released slowly and in forms available to plants.

• It increases soil organic matter and cation exchange capacity, which is simply a measurement of the capacity of a soil to hold and exchange cation nutrients such as calcium, magnesium, and potassium necessary for plant growth.

• It provides a feedstock of nutrients as well as the "habitat" for beneficial soil microbes

• It kills (some, not all) plant pathogens and weed seeds during the composting process

• It inoculates the soil with beneficial microbes (bacteria, fungi, actinomycetes, etc.)

• It improves soil structure by promoting soil aggregation (binding soil particles together), which in turns promotes aeration, moisture retention, permeability, and consistency, thus improving the "workability" of a soil.

• It is usually panacea-like in solving whatever problem your soil has.

Process and Participants

In constructing a compost pile you are setting the stage for the biological, chemical and physical decomposition of bulky organic wastes and recycling of nutrients, taking the large, the rigid, the dry (think corn stalks), as well as the particulate, the wet and the slimy (think matted grass clippings or gloppy kitchen scraps) and then transforming them.

This is a highly aerobic process, as oxygen fuels the metabolism of the microbes principal in the decomposition process. In fact, you could refer to a compost pile as a "microbial layer cake." The decomposition is carried out by succeeding waves (populations) of micro- and macro-organisms. You play the role of facilitating this process. In a sense, composting is a form of animal husbandry or "microbe farming."

As with any successful husbandry effort, habitat, diet, and water are the key building blocks of a successful compost pile. A compost pile is simply "pasture" for microbes. Via its ingredients, the pile provides a feedstock for (initially) microbial populations and eventually the "finishers" or "shredders and chewers," macro-organisms like earthworms, mites, sow bugs, centipes, millipedes, etc. Microbial populations tend to be ubiquitous, thus

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there is no need for inoculants, as small populations exist on much of the substrate used in composting.

The composting process has three distinct phases:

- 1: Mesophilic (50º–113ºF) – Moderate temperatures, usually lasting under a week
- 2: Thermophilic* (113º–150ºF) – High temperatures, usually lasting 3–4 weeks
- 3: Curing – Ambient temperatures, lasting >3 months

* small piles, made incrementally, will not get very hot

During the first phase, waves of bacteria and fungi multiply rapidly and feed on the succulent plants in the pile. When the pile is properly constructed, the first 24–48 hours feature an explosive, literally exponential growth of these organisms (bacteria can double their populations every 20–60 minutes). Often, there is no recognizable plant material in the pile after even a few days thanks to the chemical decomposition taking place. Remember, bacteria and fungi do not have mouthparts, and thus do not chew; rather, they secrete enzymes and acids that break down plant materials, and absorb the sugars and simple proteins for nutrition.

The next phase of decomposition features thermophilic, or heat-loving, organisms—still some bacteria, but increasingly, fungi. Fungi decompose (again, chemically) more complex carbon compounds such as chitin, cellulose, and lignin.

As the pile cools and begins its curing process, a third microbial population comes to the fore—a type of actinobacteria often referred to as actinomycetes. These have the simple cell structure of bacteria, but grow multicellular, hyphae-like filaments resembling fungi. Their enzymatic role is to degrade tough, resistant-to-rot woody stems and bark. Their gray-white filaments look “cobwebby” and have a pleasant, earthy smell. They can rot a redwood stake in the ground in 9–15 months.

When a pile has cooled and cured for 1–3 months, macroorganisms move in to finish the job. These organisms—mites, springtails, centipedes, millipedes, sowbugs, ants, nematodes, earthworms, etc.—are physical (as compared to chemical) decomposers. They use their mouthparts to chew, shred and further break apart resistant materials, as well as feed on dead bacteria and fungi. In doing so, they also create a softer, more “open” substrate that can be re-colonized by bacteria and fungi, which break the materials down further.

Five Criteria for Success

What are the criteria for successful husbandry of a compost pile?

1. *Pile Size and Dimensions*

Conventional wisdom now states a minimum size of 5′ x 5′ x 5′ is required for successful composting. Home gardeners, don’t despair—*ideal* dimensions are about (maximum) volume to (minimum) surface area ratios. That is, a big pile has more internal mass and thus a more hospitable decomposition environment

Abby Huetter

Chadwick Garden manager Orin Martin adds straw to a compost pile in the garden’s “compost row.”

for the microbes involved. The bigger pile also features less surface area, as the ambient environment largely degrades the pile’s surface.

That said, one of the more successful (no muss, no fuss) compost piles I have ever built was during a Garden Cruz: Organic Matters community workshop, and was a scant 2′ x 3′ x 2′. It was quick and dirty, using alternating layers of:

- 2–3″ of old horse manure
- 2–3″ of rice straw and oak leaves
- 1-2″ of really nasty kitchen scraps

plus a modicum of water

The pile heated to 140º, maintained temperatures above 130º for a month, was turned once as it cooled down and produced beautiful compost in 3–4 months. So, size isn’t everything.

Some tips re: pile dimensions:

- Oxygen does not move passively more than 3–4′ into a pile, so width should not exceed 6–8′
- It is impractical (i.e., too much heavy lifting) to build a pile more than 3.5–4′ in height
- Length is simply a function of the volume of material on hand
- Re: pile shape: a cube is better than a pyramid or tapered haystack

2. *Particle Size of Ingredients*

The principle is: the smaller the particle size (think chopping, shredding) the greater the surface area, the more the microbes can “occupy space” and thus the faster the rate of decomposition. Chopping plant material also breaks apart the rigid, often waxy outer cuticle of plants, making the succulent “innards” more accessible to the enzymatic and acidic secretions of bacteria and fungi, thus speeding and contributing to more thorough decomposition.

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3. *Aeration*

As oxygen fuels the metabolism of the decomposers in a pile, the pile construction should feature adequate pore/air space. This is readily achieved by layering together an admixture of course materials and fine-chopped materials.

Once the process is underway (1–3 weeks) a pile will settle, losing 30–50% of its volume as the materials are physically broken down. At that juncture there is usually a sharp drop in temperature. As the pile settles, reducing pore/air space, and as microbial populations exhaust the oxygen supply, oxygen becomes a limiting factor. This is an opportune time to turn and re-aerate a pile. There is often a spike in temperature associated with turning: as oxygen is resupplied, microbial populations boom—the heat generated is a byproduct of their metabolism as they continue to break down materials in the pile.

Abby Huetter

An apprenticeship student uses a machete to chop up compost ingredients into smaller pieces.

4. *Moisture*

Compost pile ingredients should be about 40–60% moisture (by weight). This equates to the consistency of a wrung-out sponge. It is best to apply water (sprinkle-spray, not drench) incrementally to each layer as you construct a pile. The moisture is for the microbes, but it also softens the pile ingredients. A note: as water will trickle down from top to bottom, apply less water to the lower layers of the pile. Also, as plants are merely supported columns of water (60–90% by weight), more water will be released into the pile as decomposition progresses. Thus, be conservative with the initial water application.

5. *Carbon to Nitrogen Ration (C:N)*

The ideal C:N ratio at the outset is suggested as 30–40:1. This means the pile has 30–40 times more carbon-rich than nitrogen-rich material by weight.

While all materials contain some carbon, carbonaceous materials (think "browns": straw, leaves, wood chips, etc.) contain primarily carbon, and similarly, nitrogenous materials (think "greens": fresh, lush plant material and animal manures) feature a high nitrogen content relative to carbon.

What is important vis a vis C:N ratio is that this is the ideal proportion to fuel the diet of the pile's microbial decomposers. In essence, they use carbon to nitrogen in a 30–40:1 ratio.

Microbes use the carbon-rich ingredients as building blocks for cellulose and, as we do, for carbohydrates that fuel their work. They use the nitrogen to build proteins, amino acids and enzymes that are necessary for cell growth, function, and reproduction. Enzymes are also key to the decomposition process; they act as biological catalysts, accelerating biochemical reactions and hastening the breakdown of organic matter. It is interesting to note that the enzymes produced by bacteria and fungi persist and function long after the producing organisms have died. In fact these same enzymes contribute to the breakdown of the "microbial corpses" that produced them.

You can achieve the desired 30–40:1 C:N ration by combining comparative volumes of carbon-rich (brown) and nitrogen-rich (green) ingredients in layers. A wide range of comparative volumes will work, from 50% carbon-based materials combined with 50% nitrogen-based materials, to as much as 80% nitrogen-based materials and 20% carbon-based materials. The pile higher in nitrogen will heat up more quickly, get hotter (130–150ºF), stay hot longer, break down faster, and kill more (but not all) weed seeds and plant pathogens.

In creating the "microbial layer cake," thin, repeated layers work best. For example:

- C: 2″ straw/leaves/wood chips, etc. (straw is a good absorptive material to use at the base of the pile)
- N: 2″ kitchen scraps
- C: 2″ straw/leaves/wood chips, etc.
- N: 6″ fresh horse manure
- C: 2″ straw/leaves/wood chips, etc.
- N: 4″ greens
- C: 2″ straw

Repeat to height of 3–4′

The pile would then feature 40% carbon-based materials and 60% nitrogen-based materials by approximate volumes and predictably, do quite well.

Note that vegan, or non-manure piles, work fine. The value of animal manures is that they are both rich in nitrogen and microbes—a sourdough starter of sorts to jumpstart a pile.

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The Home Gardener's Dilemma

Typically, home gardeners have:

- Small, incremental volumes of compost materials
- No easy access to animal manures
- An overabundance of wet, nitrogen-rich kitchen scraps
- A shortage of all other ingredients
- And a reticence to commit to composting

You can still make reasonable compost (low heat, long term) by alternating thin (1–2" inch) layers of kitchen scraps, with layers of straw or leaves (2–3"), and perhaps a little garden soil (1"). Moisten the dry ingredients as you go.

Build the pile on a 3'x3' footprint and layer (over time) to 3' high. Turn the pile once or twice. Start the next pile adjacent to the first.

In layering a pile, consider also alternating wet/dry ingredients, as well as large or bulky and small-particled ingredients. Layering approximates the much harder job of mixing, shredding, and homogenizing, the goal being to meet all five of the criteria described above at every site in the pile.

As compost is a lot like democracy—the broader the constituency base, the greater and richer the end product—it's worth stockpiling a range of ingredients to use in the home garden pile:

- A bale of straw (not hay, as hay has seeds)
- A trashcan full of leaves, wood chips, etc.
- Some bagged chicken manure

Introducing these ingredients into the mix/layering system described above will result in a better composting process and a more nutrient-rich end product. If flies or gnats are a problem, a light dusting of woodash, lime, or soil helps.

Your finished compost can be used both to fertilize plants and to improve soil structure. Before you work the soil (digging or forking), spread compost on the surface of your bed. Then as you dig it will be worked in uniformly to the depth you are working the soil. Typical intensive garden application rates are ½–2 pounds/square foot. This range is dependent on your present soil development and fertility.