

# COMPOST USE AND SOIL FERTILITY

*By Frank Mangan, Allen Barker, Steven Bodine, and Peter Borten*

## Introduction

Composting is the biological decomposition of organic materials by bacteria and other organisms. The result is a dark, somewhat nutrient-rich soil conditioner. The number of farmers using composts in their operations has increased in the last several years as they look to compost as a source of nutrients and organic matter. Some farmers make their own composts from manure and other materials that they have on their farm or obtain off the farm, whereas other farms buy already finished compost.

If you are interested in learning more about making compost on your farm, you can order hands-on manuals from the Natural Resource, Agriculture, and Engineering Service (NRAES) located at Cornell University. Two manuals available are *On-Farm Composting Handbook* (\$25.00) and *Field Guide to On-Farm Composting* (\$14.00). You can order these from the UMass Extension Bookstore, Draper Hall, University of Massachusetts, 40 Campus Center Way, Amherst, MA 01003-9244, by calling (413) 545-2717, or by sending a fax to (413) 545-5174.

Many farmers are more knowledgeable about how to make compost than they are about the nutrient availability from compost in production agriculture.

In most cases, finished compost is classified as a soil conditioner rather than a fertilizer due to the relatively low levels of nitrogen, potassium, and phosphorus. Finished compost adds these elements, and others, but releases them over a longer period of time than chemical fertilizers.

## Compost Maturity vs. Compost Quality

A compost is considered mature (i.e., finished) when the energy and nutrient-containing materials have been combined into a stable organic mass. The composting process results in a dark-brown material in which the initial constituents are no longer recognizable and further degradation is not noticeable. The length of the time needed to achieve finished compost will vary with many factors and can take anywhere from a couple of weeks to over a year.

Making sure that a compost is finished before adding it to the soil is very important. Application of an unfinished, carbonaceous compost could affect plant growth adversely since the compost may have its own demand for nutrients as the breakdown to maturity continues in the soil. In addition, immature composts made from nitrogen-rich feedstocks are often high in ammonium which can be toxic to plant growth.

Because of the risks with use of immature composts, farmers would be wise to allow a period of at least a week between application of any compost to land and planting or seeding of crops.

**Compost Quality** reflects the chemical makeup of a given compost. A compost can be mature (i.e., fully composted) but can be of poor quality due to low nutrient levels. A compost is considered stable when the temperature within a static pile remains near ambient temperature for several days, assuming there is sufficient moisture and oxygen (**See Figure 1, following page**). Unfinished compost can remain cold if moisture or oxygen are limiting.

## Availability of Nutrients in Compost

Finished compost is a dilute fertilizer, having an analysis of about 1-1-1 (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O), but varying according to the original materials that were incorporated into the pile and how they were composted.

**Nitrogen** - The nitrogen content of composts will vary according to the source material and how it is composted. In general, nitrogen becomes less available as the compost matures with nitrogen-rich feedstock but more available with carbonaceous feedstock. Nitrogen in the form of ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ) is readily available for plant absorption. However, these constituents are low in composts. A finished compost has little ammonium, as it is oxidized to nitrate during composting and curing, and any nitrate that is produced could be leached, lost to the air, or consumed by the organisms performing the composting. The

majority of the nitrogen in finished compost (usually over 90%) has been incorporated into organic compounds that are resistant to decomposition. Rough estimates are that only 10% to 30% of the nitrogen in these organic compounds will become available in one growing season. Some of the remaining nitrogen will become available in subsequent years and at much slower rates than in the first year.

**Carbon:Nitrogen Ratio** - A material having 30 times as much carbon as nitrogen, for example, is said to have a Carbon:Nitrogen (C:N) Ratio of 30:1. This C:N Ratio plays a crucial role in the availability of nitrogen in any organic material added to the soil. If the C:N Ratio is much above 30:1 microorganisms will immobilize (i.e., consume and make unavailable for plant uptake) soil nitrogen. The average C:N ratio for composts sampled on farms in 1996 was 16.9, which represents the C:N ratio that one would expect from a mature compost. However, some of the composts sampled had C:N ratios above 30:1, with one at 41:1, which would cause immobilization of nitrogen, particularly if added in large amounts to the soil.

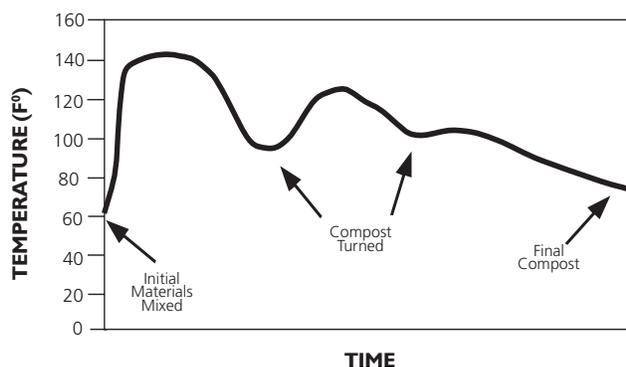
#### Nitrogen Availability

**Table 1** reports information on various components, including nitrogen, from composts sampled on farms in 1996. The average total nitrogen is 8 lb/cubic yard. Of that 8 lb, only 0.25 lb is immediately available (in the form of nitrate, 0.19 lb, and ammonium, 0.06 lb). Estimating that 10% (the low end of seasonable availability of N from compost) of the remaining nitrogen is made available in one growing season, a little more than 1 lb of nitrogen per cubic yard is available the first year (0.25 lb from nitrate and ammonium and 0.8 lb from the slow-release portion). Adding 20 tons/acre (one cubic yard is approximately 800 lb) of this compost would add a total of 320 lb of nitrogen; however, only about 42 lb of nitrogen would become available the first year.

**Phosphorus** - Similar to nitrogen, much of the phosphorus in finished compost is not readily available for plant uptake since it is incorporated in organic matter. However, not all of the phosphorus mineralized from organic matter is available for crop uptake, because some of the phosphorus released from organic matter by microbial and chemical action is quickly made unavailable by binding with other elements in the soil.

Some studies where plants have been grown with compost as the sole source of fertility added have shown phosphorus deficiency more readily than nitrogen or potassium deficiencies. Generally, farmers should consider that compost is too low in phosphorus to consider use of compost in short-term fertilization of crops and should provide an additional source of phosphorus to ensure adequate crop nutrition.

**Figure 1.** Typical time-temperature relationship for the composting process. The peaks in composting temperatures are due to heating following turning of piles.



**Table 1.** Summary of several parameters of the compost analysis taken from twenty Mass. farms in 1996.

PARAMETER	AVERAGE	RANGE
Water %	51.3	28 - 73
pH	7.1	5.4 - 7.9
Soluble Salts (dS/m)	2.8	0.4 - 19.1
Organic Matter	35.2	16.7 - 90.7
C:N Ratio	16.9	11.0 - 41.0
Total N (lb/yard <sup>3</sup> )	8.0	3.2 - 18.7
Nitrate (lb/yard <sup>3</sup> )	0.19	0 - 1.23
Ammonium (lb/yard <sup>3</sup> )	0.06	0 - 0.66
Lead (ppm)	2.4	0 - 10.5
Cadmium (ppm)	0.2	0 - 0.7

salts. There have been studies that have shown that compost used in greenhouse media can create problems with high soluble salt concentrations. Some of the composts tested in 1996 had soluble salt levels that could cause toxicity in greenhouse mixes. The electrical conductivity of a saturation extract of compost should be in the range of 2 to 4 dS/m to avoid saline injury to container-grown crops.

**Compost and pH** - The pH of finished compost is usually slightly alkaline (**see Table 1**). In general, composts will not raise soil pH to undesirably alkaline levels because of the low total alkalinity of composts. However, caution should be taken if the compost has been 'stabilized' with the addition of lime (thus increasing the total alkalinity) or with heavy applications to certain crops such as potatoes, for which the soil pH should be about 5.3. Heavy applications give rises in soil pH that might last for a growing season.

### Heavy Metals and Trace Elements

The danger of heavy metals in some composts has received much attention. At one time, some heavy metals in some composts were high enough to be toxic to plants (copper, nickel, zinc) or of concern to human health (cadmium). There have been documented cases where elements such as boron have been raised to toxic levels with repeated applications of compost. These composts with high metals or boron were made from materials with high concentrations of these elements. Governmental regulations control the materials that may be used in composts for applications to farm land. None of these toxicity problems are likely to occur with compost that has been made from farm manures or crop residues or with the commercially available composts of today. If farmers are concerned about the composition of their composts, they should have the compost analyzed at the UMass Soil and Plant Tissue Testing Laboratory.

**Potassium** - Potassium in finished compost is much more available for plant uptake than nitrogen and phosphorus since potassium is not incorporated into organic matter. However, much of the potassium can be leached from the compost since it is water soluble. In one study, potassium levels were reduced by 25% when a compost finished under cover was left uncovered in the open over a winter.

**Soluble Salts** - In general, soluble salts are not a concern from additions of composts to field soil. However, soluble salts can be a serious problem when using a compost in greenhouse mixes. Incorporation of 40 tons/acre of compost in the top 6" of field soil would be a ratio of 50 parts soil to one part of compost. Compost used in the preparation of greenhouse media will make up a much greater percentage of the whole mix and therefore will have a greater influence on all aspects of fertility, including soluble

## **Take Soil Test After Applying Compost**

A good way to evaluate the effect of compost on the fertility of a soil is to obtain a soil test after applying a compost. The soil test measures available plant nutrients, soil pH, and heavy metal accumulation in the soil.

**Compost Analysis** - In response to the increased interest and use of composts by farmers, the UMass Soil and Plant Tissue Testing Laboratory offers a compost test. The test will analyze the following: Extractable major and minor nutrients (phosphorus, potassium, calcium, magnesium, zinc, boron, iron, manganese and copper), water content, pH, organic matter, total nitrogen, nitrate, ammonium, carbon:nitrogen ratio, soluble salts, and extractable heavy metals (lead, cadmium, nickel and chromium). The current cost for this test is \$25.00.

Contact the UMass Soil and Plant Tissue Testing Laboratory to receive more information about getting your compost analyzed.