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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 clasified 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). Unfinished compost can remain cold if moisture or oxygen are limiting.

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

Availability of Nutrients in Compost
Finished compost is a dilute fertili-zer, having an analysis of about 1-1-1 (N-P2O5-K2O), 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 (NH4+) or nitrate (NO3-) 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 compost 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.

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/yard3)	8.0	3.2-18.7
Nitrate	0.19	0-1.23
Ammonium (lb/yard3)	0.06	0.06-10.5
Lead (ppm)	2.4	0-10.5
Cadmium (ppm)	0.2	0-0.7

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 sourceof 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.

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 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.

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.

UMass Soil and Plant Tissue Testing Laboratory West Experiment Station
University of Massachusetts 682 North Pleasant St. Amherst, MA 01003-9302
(413) 545-2311

Using the Pre-sidedress Soil Nitrate Test in Butternut Squash and Peppers

By John Howell

Soil organic matter, residues from cover crops and previous cash crops, and applications of manure or compost all provide nitrogen (N) for crop growth. Soil microbes consume soil organic matter as a food source and, as a result, N and other nutrients are released and made available for plant uptake. This process is called mineralization. The amount of N mineralized can be estimated and credited against the total N requirement of the crop to be grown. By crediting these N sources, growers can apply less fertilizer N without sacrificing yield. In some cases, yield and/or quality has been improved by decreasing applied N because the previous combination of fertilizer and other N sources was excessive. By reducing fertilizer N applications there is less risk to water quality and growers can save money.

It has been common for growers to apply a large portion of the required N as a pre-plant broadcast. This provides a large amount of N early in the season when crop uptake is low, which puts the N at risk for leaching unless it is protected by plastic mulch. For most crops, N utilization efficiency can be increased and leaching risk reduced by applying only a small amount of starter N at planting and providing the remainder of the required amount during the growing season as a sidedress or topdress application. However, additional N may not be necessary if sufficient amounts are mineralized from the organic sources mentioned above. The Pre-Sidedress Soil Nitrate Test (PSNT) can be used to measure the level of nitrate-N in the soil. If the soil nitrate-N level is low, the crop would be expected to respond positively to additional N, and conversely, there would not be a benefit to additional N if the soil nitrate-N levels are high.

A threshold level should exist, above which additional N application would not be expected to increase crop yield. In the Northeast, a number of researchers have established that 25 ppm nitrate-N is an appropriate threshold in sweet corn. Experience on numerous farms in Massachusetts indicates that a higher threshold is appropriate for peppers, tomatoes, and butternut squash; however, this has not been established by research.

Activities: In 1997, 1998, and 1999 plots were established in commercial butternut squash fields to test crop response to sidedressed N over a range of nitrate levels as measured by the PSNT. Samples for the PSNT were taken shortly before the grower was ready to sidedress or topdress N. In each field, one plot received no N and a second plot received 50 lb of nitrogen per acre. The squash was harvested at the end of the season and the yield of the plot with the N treatment was compared with the yield in the untreated plot.

In 1997, soils were sampled to a depth of six inches. This seemed logical because the majority of squash roots would be expected to be in this zone. However, a 12-inch sampling depth is probably more consistent and should be a more reliable tool. This is the standard sampling depth for the PSNT in sweet corn. Sampling in 1998-2000 was to a depth of 12 inches. In 1998, 1999 and 2000, similar experiments were established in commercial pepper fields and at the UMass Research Farm. In 1998, most of the plots on

one farm were lost, and the remaining plots were not sufficient to accurately analyze the data.

Results and discussion: In butternut squash, sidedressing with 50 lb N reduced yields when PSNT levels were above 60 ppm N in 1997. Where N levels were at or below 41 ppm, sidedressing generally increased yield. Research in Connecticut showed that pumpkins did not respond positively to sidedressing with N if the PSNT level was above 30 ppm N. The sampling depth used in Connecticut was 12 inches. It is expected that the concentration of nitrate-N would be lower in 12 inches than in a six inch sample, which was used in our work with butternut squash in 1997.

Soil organic matter levels and biological activity are generally higher in the upper levels of the soil and decrease as you go lower in the profile. This is a possible explanation for the lower threshold established in the work in Connecticut. Butternut squash and pumpkin have similar requirements of N and it would be expected that PSNT thresholds for these crops would be nearly identical.In 1998, the PSNT results indicated that nearly all fields with plots had N levels below the anticipated threshold of 35 to 40 ppm. Only one field was above this level at 50 ppm. There was a positive yield response to supplemental N applied at 50 lb/A in 61% of the fields with low N levels. There was a negative response in the remainder of the fields. Statistical analysis of the data indicate no significant correlation between N level and crop response to additional N in 1998. Some growers noted that there was greater than normal variability in squash fields in 1998 which probably accounts for the lack of significant correlation.

In 1999, there was a significant correlation between N level and butternut squash response to supplemental N. These results indicate when the nitrate-N level as determined by the PSNT is 30 ppm or higher, butternut squash is not likely to benefit from additional N, and that such an application is likely to reduce yield.

In 1999, there was a highly significant correlation between nitrate-N level and pepper response to supplemental N. As with butternut squash, additional N resulted in either no increase or a reduction in yield if nitrate-N level was above 30 ppm. In 2000, N levels were lower than in 1999, probably due to increased leaching from heavy rains. There was no significant correlation between nitrate-N level and response to supplemental N. This means that variation in pepper yields was not due to N treatments, but to other factors. With the cool, cloudy and wet weather that dominated the season, it is likely that pepper production was limited by those factors and N treatments could not correct for this.

Conclusions: The PSNT is a tool growers can use to optimize N application. This research, along with several years of experience, indicates that an appropriate threshold for peppers and winter squash is about 30 ppm nitrate-N. Above this level, sidedressing or topdressing supplemental N would be of no value and will likely decrease yield of butternut squash and peppers. Research in Connecticut has shown similar results in pumpkins. This can save money and time, improve crop yield, and reduce the likelihood of N leaching and water contamination. Experience over several years has shown that, barring unusual weather conditions, PSNT levels in a field tend to be fairly consistent

from year to year. Once these values are known for a field, a grower probably does not need to test every year. As a tool, the PSNT should be used along with a grower's experience and knowledge of fields. Interpretation of PSNT results should be made with regard to weather conditions. I will be happy to work with any growers who want to try using the PSNT. You can contact me at (413) 545-5307.

Building Soils for Better Crops

Editors note: Dr. Fred Magdoff of the University of Vermont was asked to highlight some of the updates in his new edition of Building Soils for Better Crops which has recently been published. This second edition, co-authored by Harold Van Es of Cornell University, was selected this year as the Outstanding New Publication by the New York State Association of County Agriculture Agents. See page box above for information on how to order this book.

Building Soils for Better Crops was written for farmers, extension agents, students, and gardeners. It is a practical guide to ecological soil management that hasbackground information as well as details of soil-improving practices. Although organic matter management is the heart of the second edition, we decided to write a more comprehensive guide that includes the other essential aspects to building healthy soils. This edition contains four chapters, two new and two completely rewritten, on managing soil physical properties. We also included four new chapters on nutrient management and one on evaluating soil health. In addition, farmer profiles describe a number of key practices thatenhance the health of their soils.

Building Soils for Better Crops unlocks the secrets of maintaining a diverse ecosystem below ground to foster healthy crops above. Ecological soil management, as detailed by the soil experts who wrote the book, can raise fertility - and yelds - while reducing environmental impacts. The 240-page Building Soils contains detailed information about soil structure and the management practices that affect soils, as well as practical information like how to interpret soil test results.

Building Soils for Better Crops is available for $19.95 plus $3.95 shipping from Sustainable Ag Publication, Box 95, Hills Bldg., Univ. of Vermont, Burlington, VT 05405-0082; 802-656-0484.

Organic Matter and its Management
Organic matter is the foundation of healthy soils. It consists of three main types of materials: living organisms, relatively fresh residues, and well decomposed, or humified, materials. We want to promote good levels of all three kinds of organic matter. A diverse population of soil organisms is one of the best ways to prevent soil-borne diseases and nematode infestations. A good supply of fresh residues supplies food to soil organisms and in the decomposition process provides nutrients to plants and sticky materials that helps develop stable soil aggregates. Well decomposed humus holds water and is a major source of soil cation exchange capacity. Good organic matter management promotes better conditions for plants,

including improved soil tilth, water storage, aeration, and plant nutrition, as well as fewer pest problems. There are three primary strategies for managing organic matter.

- Enhance additions of organic materials to soils. One of the primary management strategies is to encourage practices that increase the amount of organic residues added to soils annually. This encourages build-up of soil organic matter levels.
- Reduce losses of organic matter from soils. Losses of organic matter occur by the decomposition activities of soil organisms and through erosion of topsoil. So practices that reduce erosion and that reduce the rate of decomposition work to maintain organic matter.
- Use diverse sources of organic materials. The various types of organic residues (crop residue, animal manures, composts, etc.) have different effects on soils. Some, like dairy manure, are better at promoting aggregation, while others, like compost, may be better at suppressing plant diseases. It is through the use of diverse sources of organic materials that a diverse population of soil organisms is developed and maintained. The diverse population functions as a system of checks and balances, keeping many potential pests from developing populations high enough to cause significant crop damage.

Lessening Compaction

Frequently unrecognized, compaction can cause crop losses due to poor rooting (depth and mass of roots). In addition, compared to soils with good structure, compact soils have a much narrower range of water content for good crop growth; problems of both wet and dry conditions are more severe in compacted soils. Compaction due to harvesting vegetable crops during the narrow window is a common problem on large scale vegetable farms. The chapter on lessening compaction goes into ways to avoid compacting soils, as well as how to recognize compaction problems and what to do about them. Compaction can be reduced by staying off soils that are too wet (still in the plastic state), using controlled traffic lanes (including use of raised beds), and better load distribution, among other methods covered.

Nutrient Management

There is a chapter on general issues of nutrient management, one on managing N and P, and one on other nutrients, managing CEC, and pH. Although adding organic matter generally increases the CEC, there is also a rapid increase of CEC when you lime most soils. So there is a fringe benefit from keeping appropriate pH levels. One full chapter is devoted to soil testing. It contains everything you wanted to know about soil testing, but were afraid to ask. Why do you get different results and interpretations from different labs? Read this chapter if you want to be able to approach your soil tests with understanding common sense.

Soil Health Indicators

A chapter discusses how to make simple observations on your soil, that, together with routine soil test information, help you evaluate your present soil health. These include looking at root health, other evidence of compaction, as well as signs of runoff and

erosion, and assessing numbers of earthworms.

Five Hundred & Fiftieth ALL DAY MEETING
Saturday, December 2, 2000
Bristol County Agricultural School, Center St., Dighton, MA
Presented by New England States Cooperative Extension & New England Vegetable & Berry Growers' Association

9:30 **Registration.** There is a $10 registration fee for those who are not members of NEV&BGA. There is additional $12 fee for lunch.

10:00 **What is SEMAP All About?** James Munger, Grower, South Dartmouth SEMAP, SE Mass. Agricultural Partnership is seeking to obtain more educational & technical assistance for growers; Munger will fill us in on program to date.

10:20 **Asparagus A to Z.** Steve Garrison, Rutgers University will update us on the culture of this important crop, such as all male varieties. 11:00 Squash & Pumpkin IPM, Admire Insecticide. Ruth Hazzard, UMass has been working on developing IPM with squash and pumpkins and use of Admire insecticide. Hazzard will present a progress report. 11:30 Food Safety Issues. Nancy Cohen, UMass, will discuss what needs to be done to ensure the safety of our food supply.

11:00 **Squash & Pumpkin IPM, Admire Insecticide.** Ruth Hazzard, UMass has been working on developing IPM with squash and pumpkins and use of Admire insecticide. Hazzard will present a progress report.

11:30 **Food Safety Issues.** Nancy Cohen, UMass, will discuss what needs to be done to ensure the safety of our food supply.

12:00 **Lunch - Reservations only!** Phone reservations can be made or changed until noon on Wednesday, November 29th by calling (508) 378-2546.

1:00 **Business Meeting**

1:15 **Grower Experience with Row Covers.** Panel Discussion: Ruth Hazzard, Moderator; Philip Bartlett, Nantucket; Stephen Clegg, Seekonk; Linda Hildebrand, Food Bank Farm, Hadley. 2:00 Buying & Growing Disease Free Plants. Steve Garrison, Rutgers University. In order to produce top yields, beginning with disease free plants is a necessity. Steve will offer many suggestions.

2:20 **Flea Beetle Control on Brassicas.** Frank Mangan, UMass. Flea beetle damage is a serious problem on these crops. Frank will present his findings on recent research.

2:50 **Nitrogen Management.** John Howell, UMass. Nitrogen is one of the most important fertilizer ingredients for crop production. It is also one of the most soluble and is readily leached from the soil by rain. John will present recommendations on the most

efficient use of nitrogen.

NOTE: There will be two hours of recertification credit for certified pesticide applicators attending this meeting.

NOTE: ATTENTION STRAWBERRY GROWERS, AN IMPORTANT MEETING on Soil Pests of Strawberries. Tuesday, December 12, 2000, 8:30 a.m. - 4:00 p.m., Connecticut Agricultural Experiment Station, Valley Lab, Windsor, CT. Lunch will be provided. Six hours of pesticide recertification credit have been applied for. For more information or to register call Rich Cowles at (860) 683 4983.

NOTE: The Massachusetts Pesticide Bureau will conduct its Third Annual Waste Pesticide Collection in November at Massachusetts Highway Department facilities at the following locations: Wednesday, November 8, Northampton; Thursday, November 9, Millbury; Friday, November 10, Concord; Tuesday, November 14, Middleboro. In order to participate you must pre-register by calling the Pesticide Bureau at (617) 626-1773.

DIRECTIONS: The school is located just off Rt. 138 between Taunton and Fall River. Take Rt. 138 South from Rt. 495 or North from Rt. 195. Center Street crosses Rt. 138 at the blinker. Turn East at the blinker and the school is on the right. We are holding this meeting in Dighton to make it more convenient for growers from SE Massachusetts and Rhode Island to attend. Non-members are also invited. Please invite neighboring growers who are not members and may not know about the meeting.

Upcoming Events

January 5 Chicopee, MA. Details in December newsletter.

January 15 -22 The North American Farmers' Direct Marketing Association (NAFDMA) announces its 16th Annual Farmers' Direct Marketing Conference & Trade Show, "Diversity in the Desert." The Conference will be held just outside Phoenix in Mesa, Arizona at the Sheraton-Mesa Hotel and The Community and Conference Center. Contact: Charlie Touchette, Executive Director North American Farmers' Direct Marketing Association (888) 884-9270 nafdma@map.com For more information:www.nafdma.com or www.familyfarms.com

February 3 Waltham, MA. Details in January newsletter.

Vegetable Notes is a publication of the University of Massachusetts Extension Vegetable Program, which provides research based information on integrated management of soils, crops, pests and marketing on Massachusetts farms. Subscriptions to Vegetable Notes include the IPM Newsletter, published weekly during the growing season. For subscription information call (413)577-0712 or visit our website at http://www.umass.edu/umext/programs/agro/. For more information about the Vegetable Team's research and UMass Extension programs call Ruth Hazzard at (413)545-3696.