COMPOST PRODUCTION AND UTILIZATION

A GROWERS' GUIDE

A joint publication of the
California Department of Food and Agriculture and the
University of California Division of Agriculture and Natural Resources

Publication 21514

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Printed in the United States of America.

This publication is printed on recycled paper.

1m-rep-2/99-WJC/JL

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COMPOST PRODUCTION AND UTILIZATION

A GROWERS' GUIDE

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A joint publication of

Fertilizer Research and Education Program
California Department of Food and Agriculture
and
University of California
Division of Agriculture and Natural Resources
1995

Publication 21514

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Acknowledgments

The author would like to thank Casey Walsh Cady, David E. Chaney, Jacques Franco, Dick Gliebe, Cynthia M. Havstad, and J. Carol Hillhouse for their assistance and encouragement in the production of this publication.

Cover photos: compost turning equipment, Mark Van Horn; measuring internal temperatures of compost pile, Scott McCarthy; compost application to vineyard, Gregg Young.

Graphic Design: Pritchard Advertising, Sacramento, CA.

This publication was funded by the Fertilizer Research and Education Program, California Department of Food and Agriculture. The Fertilizer Research and Education Program was created to advance the environmentally safe and agronomically sound use and handling of fertilizer materials.

INTRODUCTION

Compost is the result of a dynamic, biological process of decomposing organic matter. It is used to improve soil properties and to supply nutrients. It is a variable commodity, and compost users need to be aware of the general guidelines regarding its production, purchase, and application. Growers also need to know how to assess the quality of these materials and how best to use them in their production practices.

The purpose of this publication is to provide farmers and agricultural advisors with practical information on the production and use of compost, including an understanding of the benefits of compost, the basic biological processes involved in its production, and a technique to determine the proportions of various materials needed to make a quality blend.

WHAT IS COMPOST?

Compost is the biologically active material that results from microbial decomposition of organic matter under controlled conditions. The production and use of compost in agriculture has many potential benefits including nutrient recycling, soil improvement, and enhanced crop growth. However, some composts of inferior quality may actually have detrimental effects on crops or soils. Understanding the composting process and the nature of various composts can help growers evaluate and use compost in ways that maximize its benefits.

Starting materials for a compost may be agricultural (e.g., manure, animal bedding, crop and processing residues), or non-agricultural (e.g., green waste, wood by-products, sewage sludge). In addition, many different composting systems are in use, and the management of these systems can vary. As a result, individual composts may differ significantly in their quality and their suitability for various agricultural and horticultural uses.

DIFFERENT TYPES OF COMPOSTING

Three general types of composting are commonly recognized: aerobic (with oxygen), anaerobic (without oxygen), and vermicomposting (composting that uses certain types of earthworms). In aerobic composting, a wide range of oxygen-requiring microbes decomposes most of the original organic matter and synthesizes new organic compounds (fig. 1). High temperatures usually are generated for an extended time, and a large amount of carbon is lost as carbon dioxide. Gaseous nitrogen losses also may be significant.

The turned windrow method of aerobic composting is the most common composting process for agricultural applications in California and is the primary method discussed in this publication.

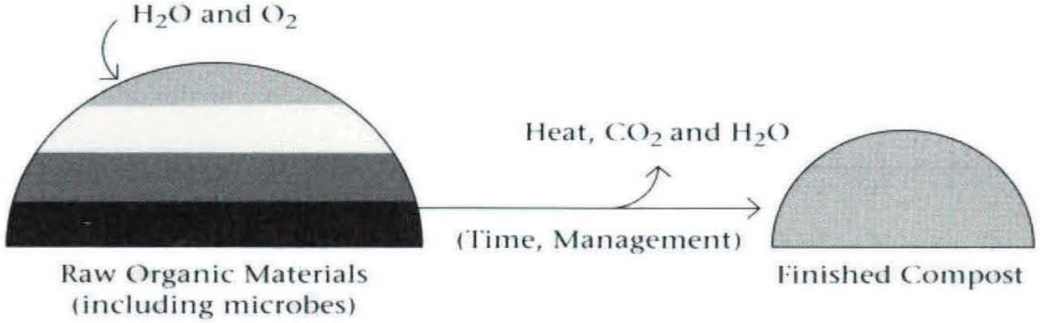

Figure 1. AEROBIC COMPOSTING can start with a wide range of organic materials. With a well-balanced carbon-to-nitrogen ratio (C:N) and proper management to ensure continuously sufficient water and oxygen, aerobic microbes transform the organic matter into chemically more complex and stable forms (humus), generate high temperatures, and reduce the amount of total material by about one-half.

In anaerobic systems, a different group of microbes partially digests, or ferments, the organic matter in the absence of oxygen. Microbial activity and decomposition are not as great as in properly managed aerobic composting systems, and temperatures do not become elevated. Anaerobic systems generate many organic acids and other compounds that may be harmful to plants. These systems may also produce biogas, which contains methane and may be used as an energy source. Anaerobic systems conserve nitrogen, and anaerobic compost may subsequently be composted aerobically to improve its agricultural utility.

Vermicomposting is an aerobic process in which certain types of earthworms digest organic matter. The product of this digestion is commonly referred to as "earthworm castings," and can be a high-quality material for enhancing soils and plant growth. Worms are sensitive to anaerobic conditions, ammonia, extremes in temperature, and lack of moisture. Worms perform best in the 60° to 85°F temperature range, and, in vermicomposting, temperatures remain near ambient levels.

ADVANTAGES AND DISADVANTAGES OF AEROBIC COMPOSTING

The aerobic composting process has many benefits. It typically reduces the weight and volume of the starting material by approximately 50 percent, thus facilitating handling. Composting can transform materials that are unsuitable for direct application to agricultural land into a valuable soil amendment. For example, high-carbon materials (e.g., straw, woody materials) can be blended with high-nitrogen materials (e.g., most fresh manures) to produce a compost with a balanced carbon-to-nitrogen (C:N) ratio. In addition, the high levels of microbial activity and associated high temperatures in well-managed compost piles can kill weed seeds and plant and animal pathogens and can degrade organic contaminants such as pesticide residues. Composting favors the production of humus, the chemically complex and most stable fraction of organic matter. Finished compost also can contain numerous microbes that serve various beneficial functions in the soil ecosystem, such as suppression of soil-borne plant pathogens.

There are also disadvantages to aerobic composting. It requires time, labor, and equipment, and many of the benefits are more difficult to quantify than the costs. Nitrogen losses during the aerobic composting process may be significant and, unfortunately, some of the management techniques to minimize nitrogen losses may retard the composting process or have other detrimental effects. In some situations, the conversion of the nitrogen in a compost pile into complex, organic forms that are not rapidly available to plants may be considered a disadvantage.

COMPOST UTILIZATION

Compost is used most commonly as a soil amendment to improve soil properties and to supply nutrients to crops. It can also be used in container mixes, as a mulch, or in other ways. Compost is typically applied to fields at rates of 3 to 6 tons/acre, although in some areas, composts or other bulk materials are applied at much higher rates (30 to 50 tons/acre). In these latter situations, growers need to be aware of the potential environmental risks.

Because compost is bulky and is applied at relatively high rates, field applications require equipment that can handle large volumes of material. Standard manure spreading equipment can be used for most broadcast applications on open ground. Special spreading equipment may be required to fit into more confined spaces in orchards and vineyards and for applications requiring specific placement of the compost. Some enterprises that haul and spread compost have equipment designed specifically for such applications.

Because the benefits of compost are greatest when it is mixed with the soil, mechanical incorporation with a disc or similar implement is very common, particularly in annual cropping systems. Usually the compost should be mixed into the top few inches of the soil, where conditions are most favorable for further aerobic decomposition. In some situations, such as in untilled orchards or vineyards, mechanical cultivation is not practiced. However, direct application of compost without mixing can still be beneficial. For example, some untilled soils may contain earthworms that are very effective in incorporating surface-applied compost and other organic residues. When the appropriate earthworms are not present, other small animals and many microbes (e.g., fungi) can simultaneously decompose organic residues and mix them into the soil. Such biological incorporation of organic materials is closely linked to the availability of water and is most rapid when there is moisture at the soil surface. Therefore, compost placement in untilled orchards and vineyards will often depend, at least in part, upon the type of irrigation system in use and its wetting pattern.

EFFECTS OF COMPOST ON THE SOIL

The addition of compost to a soil can have numerous benefits, one of the most obvious being the addition of organic matter. Many arid region soils have low amounts of organic matter, especially when under continuous cultivation. Added compost can have a significant effect on soil organic matter content. For example, the addition of 5 tons/acre of compost to the top 10 inches of a surface soil containing 1 percent organic matter would increase the total organic matter content of this surface soil by approximately 25 percent. This added organic matter will continue to decompose, or mineralize, after being incorporated into the soil. With most composts, more than half of the added compost will mineralize in the first year following incorporation, but a significant amount can also be expected to remain at the end of the season.

Adding compost to the soil will also stimulate soil microbial diversity and activity. The net effects of increasing soil organic matter and biological activity can be very beneficial. Physical properties of the soil such as structure and aggregate stability can be increased. These changes may, in turn, help improve soil porosity, water penetration and movement, and root growth. Suppression of soil-borne diseases may also result. The diverse microbial communities in composts and compost-amended soils may include organisms that reduce the size and/or activity of populations of the microbes that can cause some plant diseases. The pathogen suppression of some composts is so effective that they are used specifically for this purpose in container soils by the horticultural industry.

Because the starting materials for composts are derived from plants, they tend to contain many of the macro- and micronutrients that are essential for plant growth. With the notable exception of nitrogen, most of the mineral nutrients present in the starting materials of a well-managed compost pile are conserved during the composting process. However, there is considerable variation in the nutrient content of different composts because of the wide range of starting materials that may be used. Typical concentrations of selected minerals present in manure-based compost are shown in table 1. Nutrient concentrations of composts derived from other starting materials may be significantly different than is indicated by the figures in table 1. In particular, starting materials with nutrient contents that are lower than those of manures (see table 4) tend to produce composts that also have a lower nutrient content. Regardless of starting materials, growers should not rely on average figures when calculating the value of the nutrients in compost. Laboratory analysis is the only reliable means of determining the nutrient content of a particular compost.

TABLE 1. TYPICAL NUTRIENT CONCENTRATIONS FOR A MANURE-BASED COMPOST (DRY-MATTER BASIS)

Nitrogen	1.0 – 2.0%	Potassium	2.0 – 3.0%
Phosphorus	0.3 – 1.5%	Sodium	0.5 – 1.5%
Calcium	2.0 – 6.0%	Chloride	0.5 – 1.5%
Magnesium	0.5 – 1.5%		

BEHAVIOR OF NITROGEN AND OTHER NUTRIENTS IN APPLIED COMPOST

Well-managed and well-cured manure-based compost typically contains 1.0 to 2.0 percent nitrogen (N). Usually most of this N is in organic form and little is in mineral form. With typical compost application rates (e.g., 5 tons/acre), incorporation of compost will add a significant amount of total N to the soil, but since most of it is in organic form, it is not immediately available to plants. Thus, in contrast to mineral N fertilizers, compost applications generally do not have a large, immediate impact on available soil N.

The conversion of organic N to mineral N is called *N mineralization*. Because the decomposition of compost continues after field application, mineralization of compost N will proceed under most field conditions. However, the rate of net N mineralization from compost and manure is hard to predict. Such rates are influenced not only by the properties of a given compost or manure, but also by microbial activity in the soil. Factors such as soil type, previous field history, the current crop, weather, and management decisions all affect N mineralization rates. First-year N mineralization rates for manures can be quite variable, ranging from 20 to 90 percent. First-year N mineralization rates for composts are generally lower than those for manures with similar C:N ratios; rates for composts average from 10 to 30 percent, but significantly lower and higher numbers have been reported. The N from a given application of compost will continue to mineralize over several years.

Unless compost is applied at an unusually high rate, the N available from a single application usually will not be sufficient to supply all of a crop's N needs. Other sources of N (mineral fertilizers, green manures, or residual N from previous applications of organic materials) may be needed to supplement the N that is available from the current year's compost application. Studies have shown that when low to moderate compost application rates are used, the relatively slow N mineralization rates of composts may result in low soil nitrate (NO_3^-) levels. It is also clear that high compost application rates (e.g., 30 tons/acre) can lead to high soil NO_3^- levels. Thus, if used wisely, composts can supply a relatively stable form of N to crops that is less likely to leach than mineral N fertilizers.

The value of composts in improving soil fertility includes factors beyond their elemental nutrient content. Certain nutrients in compost can be more available than those from some other sources of these nutrients. For example, under most California conditions the availability of compost phosphorus is superior to that of rock phosphate and is comparable to that of superphosphate. In addition to serving as a source of nutrients, compost may improve the availability of nutrients already in the soil. Compost can increase the cation-exchange capacity of soils, thus allowing increased availability of certain nutrients such as calcium (Ca), magnesium (Mg), and potassium (K). Compost also can help neutralize and buffer soil pH. This may increase the availability of many plant nutrients that become less available when soils are too acid or alkaline.

COMPOST QUALITY

For any grower considering the use of compost, the issue of quality is critically important. Many factors can be considered in determining compost quality (see table 2), and their importance varies with the intended use of the compost. For example, the quality of a compost intended for field application several weeks prior to planting may not have to be as high as the quality of a compost intended for use in a container mix. The eventual quality of a compost is determined primarily by the composition of the starting materials and the composting process. Information about both of these should be made available to compost customers at no cost. Many compost producers also provide laboratory analysis data about plant nutrients, pH, salts, and other chemical, physical, and biological properties of the compost. When this information is not available, knowledge of the starting materials and composting process can give customers an indication of potential problems, and they may wish to have the compost evaluated through laboratory analysis or by other means.

TABLE 2. COMPOST QUALITY CRITERIA

Chemical	Biological	Physical
C:N ratio	Activity	Particle size
Nutrients	Weed seeds	Contaminants
Salts	Animal/human pathogens	
pH	Plant pathogens	
Metal compounds	Pathogen suppression	
Organic compounds (pesticides, etc.)	Plant response (bioassay)	

With the implementation of the California Integrated Waste Management Act of 1989 (AB 939), an increasing percentage of the organic portion of the state's waste stream, including "green material," sewage sludge, and other highly variable and complex materials, is being diverted into composting operations. Agriculture is expected to be a major user of the finished product of many of these operations. Given the diversity of raw materials and the composting processes employed, growers will need to carefully evaluate the quality of a given compost. While the old admonition, "Let the buyer beware," should be heeded in the modern compost market, the customer should not be dissuaded from seeking out (or perhaps producing) high-quality compost. For years many satisfied California growers have been using high-quality purchased compost to improve their soils and crop performance.

AEROBIC COMPOSTING

Many methods may be employed to produce compost. Aerobic composting systems can be classified as turned windrows, aerated static piles, passive static piles or windrows, and aerobic in-vessel systems. In any aerobic system, composting is most rapid when microbial activity is maximized. This is accomplished by (1) using starting materials that have the proper balance of carbon and nitrogen, and (2) keeping the compost pile moist yet well aerated (see table 3).

TABLE 3. MAIN CRITERIA FOR AEROBIC COMPOSTING

Factor	**Acceptable Range**	**Optimum Range**
Starting Materials		
C:N ratio	20:1–40:1	25:1–30:1
Particle size	1/8"–2"	varies with material
Thermophilic Stage		
Water content	40–70%	50–60%
Oxygen concentration	>5%	>10%
pH	5.5–9.0	6.5–8.0
Temperature	110°–150°F	125°–140°F

STARTING MATERIALS AND PILE CONSTRUCTION

For rapid composting, an overall carbon-to-nitrogen (C:N) ratio from 25:1 to 30:1 is considered ideal for the starting materials. If the C:N ratio is significantly below this range, N losses from the pile may be excessive; if the C:N ratio is too high, the relative lack of N can retard the early phases of the composting process. C:N ratios of common starting materials vary widely (see table 4). Materials with different C:N ratios are commonly blended in a compost pile to achieve the desired average C:N ratio (for sample calculation, see page 14).

TABLE 4. TYPICAL NITROGEN CONTENT AND C:N VALUES FOR RAW MATERIALS (DRY-WEIGHT BASIS)

Material	%N	C:N	Material	%N	C:N
Manures			Non-agricultural		
Cattle	2.5	19	Grass clippings	3.4	17
Horse	1.6	22	Fallen leaves	1.0	54
Sheep	2.4	16	Mixed paper	0.2	150
Turkey	2.6	16	Newsprint, cardboard	0.1	400+
Laying hen	6.0	6	Wood chips, shavings	0.1	500+
Broiler	2.9	14	Sewage sludge	4.5	15
Other agricultural					
Legume hay	2.5	16			
Cereal hay	1.3	32			
Legume straw	1.3	32			
Cereal straw	0.7	75			
Rice hulls	0.3	120			
Apple pomace	1.1	48			
Grape pomace	1.8	28			
Tomato processing waste	0.5	11			

The values in table 4 are representative of published figures and are intended to serve only as general guidelines. They are compiled from publications listed in the *References and Resources* section.

The composting process is also affected by the physical properties of the materials in the pile. Materials with larger and more structurally rigid particles tend to increase the amount of pore space (porosity), thus encouraging gas exchange within the pile. Because decomposition of an individual particle occurs on its surface and smaller particles have a greater surface-area-to-volume ratio, smaller particles tend to decompose more rapidly than larger ones. Also, materials that are structurally rigid tend to be chemically more resistant to microbial decomposition. Thus, the ideal physical characteristics of starting materials reflect the desired balance between providing structure to the pile to maintain porosity and having individual particles that will decompose rapidly. Materials with particles that are too large may be processed with chippers, shredders, or grinders, or, if the particle size is relatively close to the desired range, they may be blended with materials of smaller particle size. Materials with particles that are too small often can be blended with those of larger particle size. If such materials are not available, more frequent aeration (e.g., turning) may be required to maintain adequate oxygen levels in the pile. Regardless of the physical properties of the starting materials, particle size and pile structure continually decrease during the composting process.

When a compost pile is constructed with properly balanced materials and is provided with sufficient water and oxygen, naturally occurring microbes will immediately begin to decompose the materials, and their populations will increase rapidly. Some compost managers inoculate new compost piles with a small amount of material from an existing pile or with commercially available compost inoculants, preparations, or starters. Such products may be beneficial in some situations. However, because virtually all unsterilized organic materials naturally contain large numbers of decomposing microbes, successful composting does not require inoculation of new piles. As microbial activity in a compost pile accelerates, the metabolic energy of the microbes will heat the pile rapidly.

Compost windrows vary in size, depending primarily upon starting materials and turning equipment. A compost windrow can be of any length. Windrows range in height from 3 to 4 feet for dense materials with poor structure (e.g., manures) to 10 to 12 feet for very light and structured materials (e.g., leaves, straw). Most windrows, especially those blended from diverse materials, are of intermediate height. Turned windrows are typically between 6 and 20 feet wide at the base, with sloping sides. The width and height of a windrow may be limited by the size of the turning equipment.

MANAGING THE COMPOSTING PROCESS

Because composting is a biological process, it depends upon water. In managing the moisture content of a compost pile, the microbes' need for water must be balanced with their need for oxygen. The moisture content should be maintained at approximately 50 to 60 percent water on a weight/weight basis. The moisture percentage can be determined by subtracting the oven-dried weight of a sample from its fresh weight, and then dividing this difference by the fresh weight. Most experienced compost managers can estimate the moisture content of compost by feel. As a rule, the interior of the pile should be quite moist, but not so moist that one could squeeze water from a handful of the compost.

Even if the moisture content is not excessive, oxygen concentrations in the pile may be insufficient because of inadequate gas exchange between the interior of the pile and the atmosphere. In a turned windrow system, this situation is remedied though the turning process. While the actual turning process does re-aerate the pile, the oxygen introduced in this way is consumed by the microbes quite rapidly. More importantly, however, the turning process increases the porosity of the pile, thus allowing more efficient gas exchange. Turning not only enhances aeration but also re-mixes the materials. Repeated turning of the windrow ensures that all the material in the windrow is exposed to the high levels of microbial activity and high temperatures in the interior of the pile during the composting process.

In a properly constructed compost pile, microbial activity will rapidly heat the pile to 130° to 150°F within the first few days. If the pile is properly managed, temperatures will remain elevated for several weeks (with the possible exception of brief periods after turning) during the thermophilic phase of composting. Thus, the most commonly used diagnostic feature of a compost pile is its temperature. Compost temperature should be monitored frequently (at least weekly during most of the composting process and as often as daily during the initial period following pile construction) and at several places within the pile. A specially designed compost thermometer with a long, sturdy probe is necessary to measure the temperature in the middle of the pile without damaging the thermometer.

Decreasing compost temperatures, which indicate a slowing of microbial activity, most commonly result from a lack of oxygen, moisture, or adequately decomposable material. When compost temperatures drop, the cause should be determined. If it appears to be insufficient oxygen or moisture, the pile can be turned and/or water can be added. If these actions do not result in increased temperatures in a relatively old pile, the compost may no longer contain any easily decomposed material and may be ready for curing, which is the final stage of the composting process.

During curing, microbial activity, and thus pile temperatures, are reduced. In addition, different microbial populations dominate the pile and somewhat different chemicals are produced. As the compost pile cures, the humus content, cation-exchange capacity, and disease-suppressiveness of the compost may all increase. Properly curing the pile for several weeks also helps ensure the aerobic decomposition of particularly resistant particles or potentially harmful compounds that may be present if anaerobic conditions have existed in any portions of the pile. Curing can be very important in many situations, such as when using compost in container mixes or applying it to a field immediately prior to planting. Because even an excellent compost can be spoiled if it becomes anaerobic before being used, it is important to continue to manage compost piles, particularly in regard to their oxygen content, during the curing phase and until they are used.

BEHAVIOR OF NITROGEN DURING COMPOSTING

Nitrogen transformations in active and finished composts are complex, but they can be managed. For both economic and environmental reasons, minimizing N losses from composting systems is important. When excess water is added to a compost pile, either through irrigation or precipitation, the surplus water leaches through the system. This water can carry significant amounts of N as soluble organic-N, ammonia (NH_4^+), and nitrate (NO_3^-), especially early in the composting process. These nitrogen losses can be avoided by preventing the addition of excess water to the compost pile or by recycling leachate back into the pile. This will require some management, but it is certainly an achievable objective.

Controlling losses of gaseous forms of nitrogen (primarily ammonia, but also nitroxides) is not as straightforward. The ideal management system would balance N availability with microbial N demand, without deficiencies or excesses. However, this is often not possible, especially during the early stages of composting. An initial C:N ratio of 25:1 to 30:1 is usually regarded as optimum for rapid composting. However, significant amounts of gaseous nitrogen may be lost from compost piles with initial C:N ratios in this range, especially when the starting materials have high concentrations of ammonium and urea (e.g., poultry manure) and when compost piles are turned frequently. Increasing the initial C:N ratio of the compost blend (e.g., to 40:1 to 50:1) may help make the early process relatively N deficient, thus forming fewer volatile N compounds and reducing gaseous N losses. Although the C:N ratio of the pile will decrease as composting proceeds, N volatilization will be minimized because much of the N will be assimilated by microbes and converted into non-volatile organic molecules. Unfortunately, this strategy will also slow the early phase of the composting process.

An alternative strategy for minimizing N volatilization is to reduce gas exchange by less-frequent pile turning, especially during the initial stages of composting when volatile N compounds are most common. However, this practice also reduces oxygen and carbon dioxide exchange, and therefore must be used carefully to avoid the development of anaerobic conditions in the pile. Reducing the pH of the pile (e.g., below 8.5) can also help reduce ammonia volatilization by increasing the ammonium/ammonia ratio in the pile. Similarly, adding phosphate materials (e.g., rock phosphate or superphosphates) and clays with high sorptive capabilities (e.g., clay soils with high cation-exchange capacity) may help reduce ammonia volatilization.

COMPOSTING EQUIPMENT

Aerobic composting operations range in size from backyard piles to large municipal enterprises that cover several acres. A wide variety of tools and equipment is available for the various sizes and types of composting operations. For on-farm composting, equipment must be chosen that takes into account the materials to be composted, the size of composting operation, and the intended use of the compost. For smaller operations, compost piles or windrows can be turned quite efficiently with a front loader and manure spreader, particularly if the beater on the back of the spreader is modified to discharge the material directly behind the spreader. As operations get larger or more frequent turning is required, specialized equipment becomes necessary for efficient composting. Commonly used equipment includes tractor-powered turners such as PTO-driven pull-behind models (fig. 2) and self-propelled turners such as the over-the-row models. Prices for new compost turners range from approximately $10,000 to well over $100,000.

Figure 2. The PTO-powered compost turner (left) requires a tractor with a "creeper" gear that allows very slow travel. The tractor on the right is supplying water to replace moisture lost from evaporation during composting.

COMPOSTING REGULATIONS

Composting operations in California are subject to regulation by various governmental agencies, including the California Integrated Waste Management Board. These regulations may vary with the materials being composted, the size of the composting operation, its location, and other factors. Besides the requirements of state and local waste management agencies, compost producers need to comply with laws, ordinances, and regulations regarding surface and ground water pollution, odor, noise, dust and vector control, land use planning, and other relevant concerns. More specific information on laws and regulations can be obtained from the California Integrated Waste Management Board (see *References and Resources* section) or from one of the local enforcement agencies located in each county.

SAMPLE CALCULATIONS

Assume we want to blend laying hen manure with oat straw to make a compost pile with an overall C:N starting ratio of 30:1 and a moisture content of 55 percent water (see table 3 for optimum range).

We first need to calculate the proper mixture of manure and straw to achieve the desired C:N ratio and then determine if the moisture needs adjustment.

To calculate the proper ratio of manure and straw to be mixed, we need to determine the amount of nitrogen and carbon in both the manure and the straw. These could be determined from laboratory analysis, but we will assume that the figures listed in table 4 are correct for the starting materials.

Since the moisture content of most raw materials varies widely, the figures in table 4 are listed on a dry-weight basis. Therefore, in this case, we must determine the dry weight in the straw and manure. This is typically done by weighing a fresh sample of the material, oven-drying it, and then re-weighing.

In this case, we will assume that 1 pound of fresh manure yields 0.25 pound of dry manure and 1 pound of fresh straw yields 0.90 pound of dry straw.

We will then need to calculate the N content of 1 pound of fresh material using the %N information from table 4.

$$\textbf{N content of fresh material} = \textbf{(Dry Weight)} \times \left(\frac{\%\textbf{N}}{\textbf{100}}\right)$$

$$\text{N content for 1 lb of fresh manure} = (0.25\text{ lb}) \times \left(\frac{6.0}{100}\right) = 0.015\text{ lb N}$$

$$\text{N content for 1 lb fresh straw} = (0.90\text{ lb}) \times \left(\frac{0.7}{100}\right) = 0.0063\text{ lb N}$$

We can now calculate the C content of 1 pound of fresh material using the C:N ratios found in table 4 and the N content values determined in the previous equation.

$$\textbf{C content} = \textbf{(N content)} \times \textbf{(C:N ratio)}$$

$$\text{C content of 1 lb fresh manure} = (0.015\text{ lb}) \times 6 = 0.09\text{ lb C}$$

$$\text{C content for 1 lb fresh straw} = (0.0063\text{ lb}) \times 75 = 0.4725\text{ lb C}$$

With this information, we can now calculate the amount (in pounds) of fresh straw needed for each pound of fresh manure to achieve a mix with the desired C:N ratio of 30:1.

For the mix, the C:N ratio will be:

$$\textbf{C:N of mix} = \frac{\textbf{(wt of C in manure) + (wt of C in straw)}}{\textbf{(wt of N in manure) + (wt of N in straw)}} = \textbf{30}$$

If we let S equal the amount of fresh straw needed for each pound of fresh manure in the mix:

$$30 = \frac{0.09 + S(0.4725)}{0.015 + S(0.0063)}$$

Solving for S:

$$30 \times [0.015 + S(0.0063)] = 0.09 + S(0.4725)$$

$$0.45 + S(0.189) = 0.09 + S(0.4725)$$

$$0.36 = S(0.2835)$$

$$1.27 = S$$

Therefore, to achieve a final desired C:N ratio of 30:1, 1.27 pounds of straw should be used for every pound of chicken manure.

We can now calculate the percent moisture of this mix. Since oven-drying 1 pound fresh manure yields 0.25 pound dry manure, we know that it must contain 0.75 pound water. Likewise, since 1 pound fresh straw yields 0.9 pound dry straw, we know that it contains 0.10 pound water or has a moisture content of 10%.

In a mix of 1 pound fresh manure and 1.27 pounds fresh straw, the percent moisture of the mix can be calculated as follows:

$$\textbf{\% Moisture of mix} = \left(\frac{\textbf{(wt of water in manure) + (wt of water in straw)}}{\textbf{(wt of manure) + (wt of straw)}} \right) \textbf{x 100}$$

$$= \left(\frac{(1 \text{ lb} \times 0.75) + (1.27 \text{ lb} \times 0.1)}{1 + 1.27} \right) \times 100$$

$$= \left(\frac{.877}{2.27} \right) \times 100$$

$$= 38.6\% \text{ moisture}$$

Therefore, the moisture content of the mix will be 38.6%. Water will have to be added to the mix to achieve the desired 55% moisture content.

Amount of water to add to increase water content of mix to desired moisture content:

$$\textbf{Amount water needed per lb of mix} = \frac{\textbf{(desired \% moisture of mix) – (current \% moisture of mix)}}{\textbf{100 – (desired \% moisture of mix)}}$$

$$= \left(\frac{55 - 38.6}{100 - 55} \right)$$

$$= 0.364 \text{ lb water needed for every lb of mix}$$

To make further calculations, 1 gallon of water = 8.33 pounds. To determine how many gallons of water must be added to each ton of mixed material to achieve the desired moisture content of 55%, use the following formula:

$$\frac{\textbf{gallons of water}}{\textbf{needed per ton of mix}} = \frac{\textbf{2000 x (lbs of water needed per lb of mix)}}{\textbf{8.33}}$$

$$= \frac{(2000 \times 0.364)}{8.33}$$

$$= 87.39 \text{ gallons of water}$$

REFERENCES AND RESOURCES

Suggested Reading – Books:

Chaney, D.E., L.E. Drinkwater, and G.S. Pettygrove. 1992. *Organic Soil Amendments and Fertilizers*. University of California Sustainable Agriculture Research and Education Program/University of California Division of Agriculture and Natural Resources, Publication 21505.

Minnich, J., and M. Hunt. 1979. *The Rodale Guide to Composting*. Emmaus, Penn.: Rodale Press.

Parnes, R. 1990. *Fertile Soil: A Growers Guide to Organic and Inorganic Fertilizers*. Davis, Calif.: agAccess.

Rynk, R., ed. 1992. *On-Farm Composting Handbook*. Northeast Regional Agricultural Engineering Service. Ithaca, New York: Cornell University.

Suggested Reading – Periodicals:

BioCycle. JGPress, Inc., 419 State Avenue, Emmaus, PA 18049

Compost Science and Utilization. JGPress (see above).

Waste Age. National Solid Wastes Management Association, Suite 1100, 1730 Rhode Island Avenue NW, Washington, DC 20036

For information on composting regulations in California, contact:

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Sacramento, CA 95826
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