Compost Use in Florida

Produced by the Florida Center for Solid and Hazardous Waste Management for the Florida Department of Environmental Protection.
Compost Use In Florida

Produced by the Florida Center for Solid and Hazardous Waste Management for the Florida Department of Environmental Protection, December, 1998

Printed on recycled paper ©
CONTENTS

Contributors ................................................................................. 5
Figures and Tables ........................................................................ 6

Introduction
Beyond the Backyard Compost Pile ..................................................... 7

Part I: The Basics
Chapter 1: Compost and Waste Management in Florida .................. 9
Mitch Kessler and Allison Searcy
Chapter 2: What Is Compost? ............................................................... 12
Margie Lynn Stratton and Jack E. Rechcigl
Chapter 3: Developing a Market for Compost Products ................. 15
Aziz Shiralipour

Part II: Regulatory and Quality Assurance Issues
Chapter 4: Regulations Affecting Compost Production and Use .... 18
Francine Joyal
Chapter 5: Compost and Quality Assurance ....................................... 21
George E. Fitzpatrick
Chapter 6: How to Produce High Quality Compost ....................... 24
Patrick D. Byers

Part III: Agricultural Uses for Compost in Florida
Chapter 7: The Effects of Compost on Soil ....................................... 27
Aziz Shiralipour
Chapter 8: The Benefits of MSW Composts in South Florida ........ 30
Dean Richardson
Chapter 9: How Compost Benefits Citrus Crops ............................ 32
J.H. Graham
Chapter 10: Growing Field Crops with Compost ......................... 36
R.N. Gallaher
Chapter 11: Use of Composts on Florida’s Vegetable Crops ............ 39
Monica P. O’toole-Hampton and Thomas A. Obreza
Chapter 12: Compost Use for the Landscape and Nursery Industries ................................................................. 43
George E. Fitzpatrick and Dennis B. McConnell
Chapter 13: Use of Compost on Turfgrasses .................................... 45
John L. Cisar and George H. Snyder
Chapter 14: Compost Use on Forest Lands ...................................... 48
H. Reinerk
Chapter 15: Reclamation of Phosphate Mine Lands with Compost .... 51
James Ragsdale

Glossary ......................................................................................... 55
References ...................................................................................... 57
CONTRIBUTORS

Patrick Byers  
Solid Waste Authority of Palm Beach County, West Palm Beach, Fla.

John L. Cisar  
University of Florida, Fort Lauderdale Research and Education Center, Fort Lauderdale, Fla.

George E. Fitzpatrick  
University of Florida, Fort Lauderdale Research and Education Center, Fort Lauderdale, Fla.

R.N. Gallaher  
Department of Agronomy, University of Florida, Gainesville, Fla.

J.H. Graham  
University of Florida, Citrus Research and Education Center, Lake Alfred, Fla.

Francine Joyal  
Florida Department of Environmental Protection, Tallahassee, Fla.

Mitch Kessler (not pictured)  
TIA Solid Waste Management Consultants, Inc., Tampa, Fla.

Thomas A. Obreza  
University of Florida, Institute of Food and Agricultural Sciences, Southwest Florida Research and Education Center, Immokalee, Fla.

Monica P. Ozenes- Hampton  
University of Florida, Institute of Food and Agricultural Sciences, Southwest Florida Research and Education Center, Immokalee, Fla.

Andrew S. Pila (not pictured)  
Sun-Ray and Southern Farms, Lake Placid, Fla.

James Ragdale  
Sanitation Department, City of St. Petersburg, St. Petersburg, Fla.

Jack E. Rechcigl  
University of Florida, Institute of Food and Agricultural Sciences, Range Cattle Research and Education Center, Ocala, Fla.

Il Reibekof  
School of Forest Resources and Conservation, University of Florida, Gainesville, Fla.

Allison Searcy (not pictured)  
TIA Solid Waste Management Consultants, Inc., Tampa, Fla.

Aziz Shirali  
University of Florida, Center for Biomass Programs, Gainesville, Fla.

George H. Snyder (not pictured)  
University of Florida, Everglades Research and Education Center, Belle Glade, Fla.

Margie Lynn Stratton (not pictured)  
University of Florida, Institute of Food and Agricultural Sciences, Range Cattle Research and Education Center, Ocala, Fla.

Produced by the Florida Center for Solid and Hazardous Waste Management, University of Florida, College of Engineering, Gainesville, Fla.

Executive Director, John Schert  
Technical Editor, Diana Tonnese  
Graphic Design, Production Ink
Beyond the Backyard Compost Pile

The use of compost is proving to be an environmentally-friendly, potentially profitable business for Florida’s agricultural interests.

In 1992, to address the problem of decreasing space in Florida’s landfills, the State of Florida prohibited the disposal of grass clippings and other yard refuse in lined landfills. However, the ban also gave rise to a promising industry based on a natural process as old as life itself: composting. Compost, a mixture consisting largely of decayed organic material, occurs naturally every time trees shed their autumn leaves. As the dead leaves decompose, they protect and enrich the soil underneath. Now this simple, natural process is being transformed into a sophisticated science, one that extends far beyond the backyard compost heap and that offers numerous benefits for Florida’s agricultural interests and the environment.

Given Florida’s year-round growing season and porous, sandy soils, the humus-like substance which results from composting has numerous practical applications in the state. These include field crops and vegetables, landscaping and horticulture, citrus groves, golf courses, forest lands, and phosphate mine reclamation.

Florida now has 12 permitted composting facilities and dozens of mulching facilities, which help to recycle more than 1.3 million tons of urban plant debris annually. And solid waste managers are targeting other organic materials as potential candidates for composting, including food, liquid, and animal residues.

This guide presents an overview of some of the beneficial uses of compost in Florida and discusses the factors that influence the production, quality, and use of compost. Included are the results of 10 scientific studies by researchers at the Institute of Food and Agricultural Sciences (IFAS), demonstrating how compost can have a positive impact on agricultural operations in Florida. The information is intended to help agricultural interests, regulatory agencies and the general public better understand composting and the use of compost products, and its great potential in improving Florida’s soils and environment.

A note about terminology

Once considered refuse or waste, yard trimmings and other organic materials are increasingly being viewed as valuable resources to be reused and recycled. Hence, throughout this publication, the terms “urban plant debris” (UPD), “residually,” and “biosolids” have replaced the more commonly used terms “yard waste” and “sewage sludge” to reflect the changing public perception about these materials. Other helpful terminology is defined in the glossary on page 55.
Compost and Waste Management in Florida

Florida's growing population, year-round growing season, and large agricultural industry provide a unique environment for the development of organic recycling/composting programs.

Florida is the fourth most populous state and one of the fastest-growing in the United States. In mild climate and year-round sunshine attract hundreds of new residents to the state every day and over 40 million tourists each year. For Florida's solid waste managers, this booming population, plus the load from tourists, translates into a growing waste stream. In 1995, Florida's population was more than 14 million, and the total municipal solid waste (MSW) generated that same year was close to 23 million tons—a waste generation rate of approximately 9 pounds per person per day. These figures are approximately twice the national average of about 4.3 pounds per person per day.

Keeping Pace with a Growing Population

To manage this burgeoning waste stream, Florida relies on a variety of methods, including waste reduction and recycling, landfiling, and combustion. Waste reduction programs are designed to limit the production of waste, reducing the need to manage it. Recycling programs recover valuable materials from the waste stream so that the materials can be reused. Landfills serve as disposal facilities for non-recovered materials.

In an effort to maximize the recovery of valuable materials from the waste stream, in 1988, the Florida legislature enacted the Solid Waste Management Act that mandated a 30 percent recycling goal for Florida counties. The impact of this legislative initiative has been impressive. In response, counties have implemented curbside and drop-off recycling programs, encouraged recycling participation within the commercial sector, and developed a variety of urban plant debris mulching and composting programs. Today, Florida has more than 300 curbside recycling programs, 12 permitted composting facilities, and numerous other mulching facilities. According to Florida Department of Environmental Protection (FDEP) statistics, more than half of Florida's 52 counties have achieved recycling rates of 25 percent or higher.

Expanding the Focus

From 1989 to present, the amount and percentage of materials recycled in Florida has increased steadily. Despite the success of existing recycling programs, Florida's solid waste managers have their eyes on the next decade. They continue to expand their programs to target new materials and to explore other sources for the recovery of additional materials. To maximize recovery rates, solid waste professionals have turned their attention to materials which have been relatively neglected. These include paper, comprising 26.3 percent of all municipal solid waste (Figure 1-1), and construction and demolition debris, comprising 22.6 percent of the waste stream.

With Florida's warm climate and lush subtropical landscapes, urban plant debris (UPD) presents the most interesting potential for increased recycling in the state. As Figure 1-1 indicates, UPD represents 14.4 percent of Florida's MSW stream. In 1992, to encourage recycling of this valuable organic material, the Florida Legislature passed a law prohibiting the disposal of UPD in landfills designed to accept municipal solid waste. In response, the majority of Florida's counties have implemented source-separated UPD collection systems. Researchers estimated that by 1995 more than 3.3 million tons of UPD were generated in Florida every year. Yet studies indicated that only approximately 3 percent of these organics were recycled.
Undeniably, there was room for improvement. That improvement began in 1995, when the FDEP approved the deregulation of UPD composting operations, which set the stage for an industry expansion. At the same time, composters have begun focusing their efforts on establishing consistent product definitions, quality control standards, and uniform testing. If Florida’s emerging compost industry is to flourish economically, buyers of composted organic material need to know exactly what they are buying and be assured that each product’s quality is consistent. At the same time, researchers have gained their attention on evaluating the composting process and exploring opportunities for expanding its use. The commercial marketing of compost products has been encouraging. Compost has found one niche in agricultural applications in the cattle and circus industries. Additionally, favorable government purchasing policies have helped expand markets. For example, the Florida Department of Transportation has adopted specifications for composted materials and mulches made from urban plant debris, and has demonstrated the cost effectiveness and superior performance of organic compost materials in the Right-of-Way landscaping and decompaction programs. In this supportive environment, Florida can expect to continue its growth in urban plant debris processing and composting.

Anticipating Future Trends
Florida’s growing resident and non-resident population, year-round growing season, and large agricultural industry continue to provide a unique environment for the development of other organic recycling/composting programs. In addition to UPD, other organic materials are gaining notice as potentially recoverable portions of the waste stream. This renewed interest in organic materials has enhanced the development of new, innovative research and development projects, including MSW composting and vermio-composting projects. Other recent projects have moved beyond traditional urban plant debris processing and composting to target other organic materials, including food, liquid, and animal residuals. Florida’s organic recycling programs continue to expand with the support of innovations in collection methods (especially co-collection of organics in split collection vehicles), and increased on-site processing. For organisms recycling to occur, compost safety standards must be defined, and safe, economically sound uses for compost must be identified through coordinated research programs. Such a market development research effort is under way through a partnership involving the Florida Department of Environmental Protection, the Florida Center for Solid and Hazardous Waste Management, and the University of Florida’s Institute of Food and Agricultural Sciences.

Perhaps the most important factor influencing developments in Florida’s solid waste management practices is the increasing pressure to improve the efficiency and accountability of municipal solid waste management programs. Variable rate collection programs are expected to grow, driven by the push for greater reduction in sources, and an increase in return on investment. In Florida’s present economic, legislative and regulatory environment, the future for recycling organics looks particularly bright. In sum, Florida’s composting industry is like a sleeping giant about to awaken to a coming decade of healthy growth and stability, because when recycling of organics will play an increasingly important role in managing Florida’s MSW stream.

Compost Operations in Florida
Florida, home to some of the largest and most successful commercial composting facilities in the United States, is among the nation’s leaders in composting. For example, the Enviros Care facility in Jacksonville, which produces 40,000 tons of compost per year, is one of the largest composting facilities of urban plant debris (UPD) in the country. The Palm Beach County Solid Waste Authority, producing 60,000 tons of compost per year, operates one of the nation’s largest and most successful composting facilities (biological and urban plant debris).

Another of Florida’s claims to fame is the Satellite Beach Solid Waste Authority’s composting facility, begun in 1989, that has the longest operating experience in MSW composting. In all, Florida has 83 compost facilities (Ken McIntyre, personal communication: Composting News, Ohio), which contain everything from food residuals to industrial waste.

Food refuse composting: Three Florida composting facilities reportedly compost food residuals (Goldstein and Block, 1991a). One, a municipal facility operated by the Soil and Water Conservation Districts in Homestead Florida, processes waste from a correctional facility. Another, Ready Creek Energy Services of Lake Buena Vista, Florida processes food refuse from Disney World (Goldstein and Block, 1992a). A third, Environmental Earthworm Projects, Inc. in Orlando, composts fruit and vegetable trimmings from food processors and urban plant debris.

An additional food refuse composting facility is being considered in Central Florida. If this site is developed, it is expected to handle the urban plant debris, food refuse, and biosolids for 7 correctional facilities.

Biosolids composting: As of December 1997, nine operational biosolids composting facilities were reported in Florida (Goldstein and Block, 1992b). They include Cooper City Utilities, Everglades Meadows Utilities, Miami-Dade Water Sewer, South Point, Nocatee, Ocoee, Palm Beach County, Reedy Creek, and Sarasota. Two facilities, Arupka and Miami, are in the planning stages.

Industrial composting: Industries in Florida include food processing, beef food processing, beef packing, dairy, and beef packing facilities. Effluent from meat packing facilities is also being composted.

Mower Composters are training during a five-week, 25-hour course using a comprehensive handbook and interactive, varied composting demonstrations and workshops. Graduates then donate 25 hours of time helping to organize and teach other composters. Graduates also receive a backyard compost bin. (Polly Ryan, Hillsborough County Cooperative Extension Service, personal communication).

Compost education. Along with the Master Composter Program, associations such as Florida Organic Growers Association (FOGA) and institutions such as the University of Florida’s Institute for Food and Agricultural Sciences publish and supply educational resources for workshops and conferences with the goal of educational outreach. Much more outreach is expected in compost education in the near future.

MARGIE LIND SWATON and JACK E. REDDICK
PAP: THE BASICS/CHAPTER 2

What is Compost?

Once considered waste products, composted urban plant debris and other organic materials have the potential to breathe new life into Florida's sandy, nutrient-poor soils.

Margie Lynne Stratton and Jane E. Reichilg
University of Florida/Institute of Food and Agricultural Sciences
Range Cattle Research and Education Center
Oviedo, Florida

Composting is a biological process in which microorganisms convert organic matter into a stabilized, humus-like substance. Many of the organic materials used for composting are inappropriate in their raw form for use on land or around living organisms because of the presence of odors, weed seeds, human pathogens, and storage and handling constraints. Composting helps to break down organic residues, stabilize nutrients, destroy weed seeds, and control possible toxins or diseases (Barker, 1997; Stratton et al., 1995; Hoitink and Keener, 1993; Haug, 1993). The resulting compost has numerous horticultural and agronomic benefits and is environmentally safe for use on soils around plants, humans, and animals (Stratton et al., 1995; Barker, 1997).

Controlled decomposition occurs as the result of the activities of naturally occurring macro- and microorganisms (Figure 2-1). Bacteria, actinomycetes, and fungi are the primary microorganisms involved in decomposition. To grow and multiply, these microorganisms require carbon as an energy source, nitrogen to build proteins, moisture, and oxygen. Enzymes, the active proteins, are produced by bacteria and assist in breaking down complex carbohydrate degrades into simpler forms, which bacteria can use for food. The nutrients that become available during decomposition remain in the compost within the bodies of new microorganisms and as humus. Not all decomposition is microbial; in fact, it starts with macroorganisms, including earthworms, grubs, millipedes, springtails, and centipedes, which assist in the process by digging, chewing, and mixing compostable materials.

The composting process does not stop at a specific point but continues until the remaining nutrients are consumed by the last remaining organisms and most of the carbon is converted into carbon dioxide and water (Ryken, 1992). Compost has many beneficial uses. Compost improves soil aeration, soil drainage, the water-holding capacity of sandy soils, the percentage of organic materials in soils, and the ability of soils to absorb and hold nutrients.

Composting Past and Present

The simplest form of composting — the decomposition of plant materials where they fall — has been occurring naturally for millions of years. In natural settings, such as under forest canopies, composting occurs as leaf litter decomposes into humus. With the advent of crop cultivation and animal husbandry, the resulting plant residues and animal manures were sometimes decomposed by gathering them into mounds or piles to allow composting to occur.

Farmers, greenhouse operators, nursery crop managers, landscapers, orchardists, backyard and organic gardeners have been making small compost heaps informally for decades, often simply to save the cost of transporting and disposing of the materials. During the past few decades, composting has become a sophisticated and somewhat well-researched science. And while composting is still practiced on a backyard or small-farm scale, more and more often, it is now carried out on a large scale as part of local municipal waste management programs. On a municipal level, composting operations usually require sophisticated machinery and engineering (Stratton et al., 1995; Hoitink and Keener, 1993; Haug, 1993).

The first recorded method of composting community wastes was developed in India by Sir Albert Howard in 1925. This method, called the Bangalore or Indoore system, simply involved alternate layering of wastes in trenches. Over time, as the scope and scale of composting increased with the amounts and types of waste products handled, innovative methods were devised to speed or ease the process. The layers were mounded, spread, aerated with forced air, turned, enclosed, exposed, chopped, ground, dried, wet, sifted, dumped from platforms, conveyed up belts, or separated at the source, for example. For the most part, the various processes were named for the company or inventor involved with the latest innovation and are summarized in a review article by Stratton et al. (1995).

In the United States during a recent 5-year period, composting facilities have increased from 2,200 to almost 3,500 (Christopher and Asher, 1994; Ken McEntee, personal communication). During the 14 years prior to 1997, biosolids composting facilities have increased from 90 total projects nationwide (61 operating facilities) to 332 total projects (262 operating facilities) as reported by Goldstein and Block (1997b). Seven states reported a decrease in biosolids composting from 1996 to 1997 (Goldstein and Block, 1997b).

Compost Materials

Any number of materials, or feedstocks, can be composted, including grass clippings and other types of urban plant debris, biosolids (commonly known as sewage sludge), and other organic materials. Recently, there has been an increased interest in composting municipal, industrial, and agricultural by-products (Stratton and Reichig, 1998). Municipal solid waste, commonly called trash or garbage, has been composted and applied to many crops, including forage pastures, with improved yields and other benefits (Shiraliour et al., 1992a; Stratton and Reichig, 1997). Coal bottom and fly ash, cement kiln dust, biosolids, water treatment sludges, food processing by-products, animal and plant residues, by-products from metal smelting, paper and wood industries by-products, tannery sludges, textiles production by-products, rock dusts, chemical and drug production by-products have all been composted and land-applied (Stratton and Reichig, 1998).

Unfortunately, not everything that can be composted is composted. Barker (1997) estimates that 827 million tons of compostable materials are produced each year, largely by agriculture, municipalities, and industry. However, only 140 million tons, or 17 percent, of those are collected for composting.
Developing a Market for Compost Products

The potential market for compost products in Florida is great. The challenge is convincing the consumer to use compost. The growth of the compost industry in the United States and Florida is being driven by the increasing cost of landfilling waste, public support for resource conservation, and legislative mandates for waste diversion — not by demand for compost products. Yet if compost is to become a valuable resource to be managed for profit, new markets for its use must be developed.

How Much Compost Can Florida Handle?

In 1996, about 23 million tons of MSW were collected in Florida (FDEP, 1997). Researchers estimate that, if the organic fraction of this waste stream were to be biologically decomposed, about 5.5 million tons of compost would be generated. But key questions remain. Specifically, is the market capacity in Florida sufficient to use the compost produced? What is the present market capacity for composted products? How can Florida build markets for composted products?

According to one study (Sivitik et al., 1992), the state’s agricultural industry alone could use more than 20 million tons of compost each year. And statewide, as many as 42 million tons of compost could be used annually within a 50-mile radius of urban centers with populations of more than 100,000. The researchers imposed the distance constraint of a 50-mile radius based on the perceived limited economic viability of shipping farther than 50 miles. In other words, the potential use for composted products in Florida is more than 7.5 times the amount of compost that could be produced each year.

In 1992, the average annual rate of compost penetration in U.S. markets was less than 2% of its potential uses (Sivitik et al., 1992). If the rate of compost penetration in the Florida market follows the national trend, compost use in the state is only about 840,000 tons a year. Clearly, Florida has a market development challenge, not a lack of market.

Developing a Viable Market

For any type of compost to be marketable, regardless of origin, it must pass minimum product standards for protection of public health and the environment. And commercial compost must consistently meet the requirements of end uses, which may vary widely. Many communities are finding it necessary to meet or exceed all the requirements, and then put additional efforts into marketing strategies that involve education and market development.

The long-term feasibility of commercial composting depends largely upon building a market by demonstrating safe use and establishing benefits, both practical and financial. Table 3-1 outlines the steps recommended for successful compost market development.

Establishing Market Niches and Overcoming Barriers

New commercial composters are discovering that not all compost uses are created equal. Each requires a specific product, and the range of quality may vary widely. For example, high-value end-uses, such as a growing medium for landscape nurseries, require refined, mature, high-quality composts. On the other hand, lower-value end-uses, including use as a landfill cover or in reclamation of surface mines, can accept any class of general-use compost. Experienced compost marketers have discovered that a low-quality compost will
### Chapter 3: Developing a Market for Compost Products

#### Table 3.1.

<table>
<thead>
<tr>
<th>Steps for Successful Compost Market Development</th>
<th>Benefits</th>
<th>Associated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Conduct Market Assessments</td>
<td>Increased water-holding capacity</td>
<td>Water conservation</td>
</tr>
<tr>
<td>A. Identify market requirements for compost product(s)</td>
<td>Increased cation-exchange capacity</td>
<td>Fertilizer savings</td>
</tr>
<tr>
<td>B. Assess market capacity (current and potential)</td>
<td>Improved plant growth response</td>
<td>Yield increase</td>
</tr>
<tr>
<td>C. Demonstrate the absence of odors and pathogens</td>
<td>Suppression of diseases</td>
<td>Pesticide reduction</td>
</tr>
<tr>
<td>II. Conduct chemical analyses on compost and plant tissues</td>
<td>IV. Develop ongoing working relationship with end-users through educational programs</td>
<td></td>
</tr>
<tr>
<td>A. Demonstrate the limits in heavy metals and toxic material content</td>
<td>A. Workshops</td>
<td></td>
</tr>
<tr>
<td>B. Demonstrate the absence of odors and pathogens</td>
<td>B. Field days</td>
<td></td>
</tr>
<tr>
<td>C. Define methods to assure maturity and stability</td>
<td>C. Fact sheets</td>
<td></td>
</tr>
<tr>
<td>III. Demonstrate the benefits of compost application and the values associated with these benefits</td>
<td>D. Media outreach to grower associations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E. Publication of findings in regional newsletters and trade journals</td>
<td></td>
</tr>
</tbody>
</table>

Not be marketed successfully to high-value end-users, nor will a low-value end-user pay the premium price for high-quality compost. Yet both groups will require a safe and reliable product.

### Easing Concerns Over Compost Quality

Quality is a function of the physical, chemical, and biological characteristics of compost. Desirable physical characteristics of compost include a dark color, uniform particle size, a pleasant earthy odor, the absence of physical contaminants (such as glass or plastics), consistency, and moisture content of approximately 50%. Desirable chemical characteristics include balanced nutrient levels (nitrogen-phosphorus-potassium, and other elements) and low levels of heavy metals, PCRs, pesticides, and salts. In terms of desirable biological characteristics, the compost must be mature, with high organic-matter content, and be free of pathogens and weed seeds.

One of the most important steps in improving compost quality is minimizing the presence of hazardous materials such as heavy metals. The highest quality compost will have the lowest levels of potentially harmful contaminants — particularly heavy metals and physical contaminants — as derived from source-separated organic materials that were not mixed with other materials during collection or composting.

Following the trend in Europe, the United States is beginning to move away from mixed MSW and toward source-separated organic composting. (For more on quality assurance of compost, see page 21.)

### Meeting the Needs of the Consumer

As with all successful products in the marketplace, compost must meet the requirements of the end-user. Three factors are of particular importance to compost users: availability, cost, and quality. Compost must be consistently available for end-users when they need it. If they choose to haul it themselves, it must be in an easily accessible location. The cost of compost is a composite of the costs of the product, its transportation, and its application. Although availability and cost are important factors in the development of compost markets, it appears that quality may be the decisive factor. It is often stated that high-quality compost will always find a market.

### Teaching Consumers to Trust Compost

Communities with commercial composting facilities have discovered that producing the finest product and making it conveniently available are not enough to entice some potential consumers to try compost. A solid educational program is necessary in order to substantiate the benefits of using the product. Fortunately, scientists and educators at the Institute of Food and Agricultural Sciences at the University of Florida (Smith and Shiralipour, 1997) have done much work in communities to build convincing arguments that commercial composts are safe and can be used beneficially.

(Ullalhe 1995). First, the IFAS team designed a set of projects to demonstrate the absence of pesticides in commercial composts and is now studying the process for biological remediation during composting. Additionally, the scientists proved that they could measure compost maturity and stability and indicate nitrogen availability. Next, they demonstrated low levels of compost toxic metal contents and the low levels of these metals in crop parts. Finally, they established that applying compost improved physical and chemical properties of soils for vegetable crops, assisted in retention of water and nutrients in turfgrass soils, and helped establish woody ornamentals in landscape beds. Through the efforts of IFAS scientists, communities now have the educational tools they need to convince potential consumers that applying mature compost is a beneficial and economically viable alternative to conventional soil treatments.
Regulations Affecting 
Compost Production and Use

State Environmental Requirements
Two Department of Environmental Protection (DEP) regulations specifically address compost use in Florida, depending on the feedstock processed into the compost product. These are Chapter 62-709 (Criteria for the Production and Use of Compost Made from Solid Waste) and Chapter 62-640 (Domestic Wastewater Residuals), Florida Administrative Code (F.A.C.). Copies of these rules can be obtained from the Department's website at http://www.dep.state.fl.us or from one of the DEP District Offices.

Solid waste
State regulations governing the use of compost made from solid waste are found in Chapter 62-709, F.A.C. The majority of this chapter contains requirements for the compost-producing facility itself. However, this rule also contains a classification scheme and use restrictions based on the type of compost produced.

Compost made from solid waste is classified based on the type of waste processed, compost maturity, stability, the presence of foreign matter, the size of holes in the sieved used to screen the compost, the organic matter content, and the concentration of heavy metals. The concentration codes used in the classification scheme are identified in Table 4.1. The values for "Exceptional Quality" limits specified in the federal regulation are included in this table for comparison.

Table 4.2 illustrates the classification scheme for compost materials. The requirements for Types Y and Type YM are identical. However, a classification for "yard trash only" was mandated by the Florida legislature.

Compost maturity, for purposes of this regulation, is determined by whether the compost will reheat to more than 20 degrees Centigrade (36 degrees Fahrenheit); above ambient temperature and the percent reduction is organic matter. Classification of a compost made from solid waste affects how it can be used. Only such composts classified as Y, YM or A have unrestricted distribution. Types B and C are restricted to use by commercial, agricultural, institutional or governmental operations. In other words, the only restriction placed on Types B and C is that they cannot be distributed for use by the general public. Further, only Type B can be used in situations, such as in a park, where contact with the general public is likely. Compost classified as Type D can only be used at landfills or land reclamation projects where contact with the general public is not likely.
Finally, any solid waste compost classified as Type E must be disposed of in a landfill unless it can be demonstrated that its use will not harm the public or the environment. Most compost products made from solid waste have been classified as Types Y, YM or A. There are also restrictions regarding the total amount of heavy metal that can be applied to soils. These restrictions, expressed as pounds per acre, are cadmium — 4.45; nickel and copper — 11; zinc — 222; and lead — 445. As these values are based on the most restrictive soil cation exchange, the rule also contains a provision that allows a user to demonstrate, through an analysis of the cation-exchange capacity and other physical and chemical characteristics of the receiving soil, that a higher application rate would still provide in equal degree of protection.

While this section discusses the current requirements, the concentrations for heavy metals in the classification scheme were established in 1989 and were based on the criteria used to regulate biosolids prior to adoption of 40 CFR Part 503 by the Environmental Protection Agency. These EPA standards were also used in the DER's Residuals Rule, Chapter 62-640, F.A.C. Further, not only are the classification concentrations in the Solid Waste Compost Rule out-of-date, they are also based on different risk assumptions and methods of calculation than are the Soil Cleanup Target Levels used for other reuse type decisions within the Division of Waste Management. Given that Rule 62-709.600(8), F.A.C., stipulates that "compost shall not be used in any manner that will endanger public health and welfare and the environment," and given the need for consistency within the Division for approving reuse projects, it is anticipated that rule development will be initiated to update this rule and to incorporate the Soil Cleanup Target Levels for heavy metals in compost.

Biosolids State of Florida regulations governing the use of biosolids are contained in Chapter 62-640, F.A.C. The DEP Division of Water Facilities provided a summary of regulations affecting biosolids use in Biosolids Management in Florida: Beneficial Use of Domestic Wastewater Residuals (DEP May 1997).*

Chapter 2 of that document "Regulations Affecting the Beneficial Use of Residuals," addresses residuals classified as "Class A" or "Class B" under both state and federal regulations, and residuals classified as "Class AA" under state regulations. In summary, only biosolids that have received the highest degree of treatment for pathogen reduction and that also meet the most stringent pollutant limits specified in the regulation are designated as Class AA. Most or all of the biosoloid compost currently produced in Florida meets the Class AA requirements. These residuals are subject to the "Exceptional Quality" limits specified in the federal regulations and the Class AA limits listed in the state rule. While use of biosolids meeting these criteria does not require an Agricultural Use Plan, nutrient content information and recommended application rates must be provided to the user.

A Matter of Safety It is important to remember that the criteria established in the environmental regulations address product safety and not the requirements of a particular end-user.

C

*Copies are available free of charge from the DEP's Bureau of Water Facilities, 2600 Blair Stone Road, Tallahassee, FL 32399.

Compost and Quality Assurance

Compost products made with an emphasis on quality and consistency will have no shortage of uses or users.

Composts are made from a changing assemblage of organic feedstocks. For this reason, there can be a great deal of variation in the chemical and physical parameters of compost. The quality of the compost can influence the soil's pH, soluble salt levels, exchange capacity, aeration, particle size distribution, bulk density and water-holding capacity. Consequently, the highest quality compost products frequently compare favorably with peat and other high value organic substrates. The low quality compost materials may retard plant growth, and, in extreme cases, may contribute to plant mortality. Plant producers should be aware that certain quality parameters can make the difference between successful and unsuccessful use of compost products.

Assessing Compost Quality Parameters

Compost products are used in four general ways: (1) as a stand-alone container growing medium, (2) as a component in a container growing medium mixture, (3) as an organic top dressing, and (4) as an incorporated soil amendment. Although there is no perfect growing medium for all crops under all growing conditions, numerous authors have described general recommendations. For example, for container grown foliage crops, Joiner (1981) recommends the following general parameters: bulk density: 0.30 grams per centimeter cubed (g/cm³) (dry), 0.60-1.20 g/cm³ (wet); percent pore space: 5-30%; percent water-holding capacity: 20-60%; pH: 5.5-6.5; soluble salts: 400-1,000 ppm; cation-exchange capacity: 10-100 meq/100 cm². A variety of plant species are sensitive to high salt concentrations. Salts in the growth medium disrupt water uptake or directly affect the physical functions of plants. If these types of plants are exposed to high salt concentrations, their growth might be suppressed or ceased. Therefore, composts with high salt concentrations could cause toxicity in sensitive plant species. Even a high rate of compost application with low salt content might cause injury in such plants. Thus, a high quality compost physically may be low quality if the salt concentration is high. Of the four general uses for compost, the stand-alone container growing medium category requires the highest quality compost. When compost products are used as components in growing medium mixtures or are applied directly to agricultural soils, a lower quality of compost product may be acceptable. For example, Styn et al. (1992) indicate that a soluble salt concentration of less than 2.5 percent per m (dS/m) is necessary for a stand-alone container medium, but a value of less than 6.0 dS/m is acceptable when the compost product is to be used as a component in a growing medium mixture, and a value of less than 20 dS/m is acceptable when the compost product is to be used as an incorporated soil amendment. If salt levels are a concern, it is wise to wait until a rain or other watering event occurs to dilute the salts. Numerous factors can influence the likelihood that any compost product will have sufficient quality as a rooting medium. These include the parent material from which the compost product was made, the preprocessing and postprocessing procedures to which the substrate was subjected, the amount of time of active composting and the maturity of the compost product, the amount of inert material in the compost product, the
concentration of regulated elements (heavy metals), and the presence of pathological microbiological organisms.

Parent Material
The composition of the parent material can sometimes influence the quality of the compost product. The parent material may affect the particle size, nutrient content and soluble salts in the final product. Very fine composts tend to separate and block drainage in pots, while a compost with coarse, friable properties creates a porous medium that facilitates drainage. For example, a compost made from highly decomposed sewage sludge supports more rapid growth in container-grown viburnum (Viburnum suspensum) than do composts made from nitrogen-poor materials such as garbage, urban plant debris, and stable swineure (Fitpatrick and Verkaik, 1991).

Preparation and Postprocessing
Procedures employed at the composting facility before and after the active composting period can sometimes influence compost quality. For example, sludges from municipal treatment plants are usually mixed with materials to control pH and conditioned prior to composting. If a sludge is stabilized by treatment with ferric chloride and lime, the resulting product can be used in many wastewater treatment facilities, the level of soluble salts in the finished compost product may be significantly reduced. When compost is made from sludge that had been stabilized using a wet-dust oxidation process. When composts made from sludge treated with stabilization and conditioning processes previously used to grow the non-salt-tolerant container crops Spathiphyllum 'Mauna Loa' and Schaefferiana arborea, plants grown in the compost with higher soluble salt levels were significantly smaller than plants grown in composts with lower soluble salts (Figure 5.1). However, both compost products resulted in plants that were significantly larger than those grown in a control medium consisting of 40% peat, 50% pine bark and 10% sand (Fitpatrick, 1986).

Other processing procedures, such as screening, can influence the physical quality of the compost products by making them more homogenous and, consequently, easier for the grower to mix and apply. Smaller plants usually require composts that have passed through small diameter screens. Plants grown in large tubs or in soil with incorporated composts may do well with coarser material.

Active Composting Time and Compost Product Maturity
The earliest reference on composting time published in the modern era (e.g., Howard and Wed, 1931) indicate that an optimum composting time of approximately 6 months for mixtures containing 25% of high nitrogen material, such as manure, straw, and 75% of high carbon material, such as plant debris. Many current commercial compost producers promote a stabilized end product in a much shorter period because of the capability for preprocessing, mixing, aerating, and managing moisture content. Producers may feel a strong economic incentive to accelerate active composting into the shortest possible time period. If the processing time is too short, an immature compost may result. Commercial plant producers who purchase compost products from such sources must be mindful of the negative effects associated with the amount of inert materials allowed in compost products. In Florida, state regulations mandate that inert materials may not exceed 20% by weight, in compost products marketed for unrestricted horticultural uses. In other areas, compost producers and brokers have developed self-regulating programs. For example, compost producers in Ohio will not sell a compost product for nursery use if the inert material level exceeds 0.5%, by weight (Tyler, 1993).

Regulated Elements
One of the most universal concerns related to compost use is the question of regulated elements. The U.S. Environmental Protection Agency has issued recommendations for the maximum permissible levels of 10 heavy metals in compost products: arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium and zinc. Many states have passed their own regulations, using the federal recommendations as guidelines. While there can be substantial differences in heavy metal concentrations between different types of compost products that may be attributable to the parent material and the relative level of preprocessing, the overwhelming majority of compost products available at the present time fall well within federal and state guidelines (Chaney and Ryan, 1993). In fact, commercial compost in Florida are required to meet these guidelines.

The safety of compost products is further assured by the reduction of toxic heavy metals in waste streams brought about by the implementation of industrial pretreatment programs, as well as by quality control programs practiced by commercial compost producers and monitored by governmental regulatory authorities.

Biological Status
A common concern held by many people relates to compost use is the possible presence of pathogenic organisms. The high temperatures reached during active composting (from 130 to 140 degrees Fahrenheit) have been shown to reduce to insignificant levels any pathogens that might have been present in the parent material (Burke, 1983; Haug, 1993). However, since commercial composting is frequently conducted on a large scale, involving hundreds of tons per day, questions have been raised about whether cool spots exist in places within active compost piles and whether pathogenic organisms could reintroduce the final product. These issues are normally addressed by examining representative samples of compost products and conducting microbiological screenings. Usually, the pathogens themselves are not cultured. Rather, the compost samples are tested for the presence of indicator organisms, such as fecal coliform bacteria. Indicator organism tests are simple, reliable and are required to be conducted in federal and state regulations. They serve as an additional safeguard to ensure the maintenance of compost quality and safety.

Another microbiological issue of concern is the presence of the ubiquitous thermotolerant fungus Aspergillus fumigatus, a saprophyte frequently found in decaying organic materials. A. fumigatus is one of the relatively few fungi that can be pathogenic to humans, since the human body temperature, 37 degrees C, is in the optimum temperature range for growth (Oliver, 1994). However, the relatively small number of confirmed cases of aspergillosis, coupled with the ubiquity of A. fumigatus in the environment, implies that the susceptibility of humans is rather low. A recent review of the literature indicates that humans with suppressed immune systems may become ill after only minimal exposure to A. fumigatus. But healthy individuals from the general population appear to show no significant health impacts from exposure to this fungus (Maritato et al., 1992). Moreover, the average horticultural worker is exposed to many substrates containing A. fumigatus, such as soil, peat, sawdust wood chips, and other products. If horticultural workers do not experience any aspergillosis symptoms from contact with these kinds of products, it is not any more likely that they would experience symptoms as a result from exposure to compost products.

Weed seeds are also a concern. Shirali (1990) and McConnell placed weed seeds in plastic mesh bags, which were then placed in compost piles. Exposure of the weed seeds to temperatures of 130 degrees Fahrenheit for only a few hours was adequate to kill the weeds.

Growing Possibilities for Quality Compost
The potential for using compost by agricultural interests is great. If compost products are made from an emphasis on quality and consistency, it is likely that use of these materials will continue to expand in crop production. ①
PART 2: REGULATORY AND QUALITY ASSURANCE ISSUES/CHAPTER 6

How to Produce High Quality Compost

The right mix of raw materials combined with state-of-the-art technology yields a high quality end product.

PATRICK D. REES
SOLID WASTE AUTHORITY OF PALM BEACH COUNTY
WEST PALM BEACH, FLORIDA

A compost recipe usually is a combination of organic materials, or feedstocks, capable of producing a balanced end product, one that is nontoxic to plants, people, and animals and that improves soil quality. Common fodder for composting includes tree bark, manure, leaves, cardboard, food waste, soiled paper, wastewater residuals (biosolids), grass clippings, tree trimmings — in effect, just about anything organic and biodegradable in high capital construction costs. Most are proprietary systems that require great operational and maintenance expertise and a higher skill level to operate.

Once a recipe has been established, the mixture will be incorporated into the compost technology chosen, either windrow aerated static pile, or in-vessel composting. These technologies were designed to accelerate the decomposition process of organic materials. How these processes are managed will either speed up or slow down the decomposition process, ultimately influencing the quality and cost of the product.

Digestion

During the composting process, microorganisms occurring naturally in organic materials transform them into compost through digestion. That is, the microorganisms break down the various organic materials into simple compounds that are more uniform and biologically less active. In order to accelerate the composting process, these microorganisms need an environment that allows them to flourish.

The main aspects for proper management in the composting process include temperature, aeration, and moisture control. Low temperatures are indicative of reduced microbial activity and could indicate a lack of oxygen or inadequate moisture conditions. Most often, low temperatures are the result of lack of oxygen.

Once the composting process is believed to be complete, testing should be performed to ensure that the composting goals have been met and the desired compost is produced. Common test methods measure the carbon-to-nitrogen ratio, respiration rate, moisture, pH, and weed seeds. Additional tests are run based on regulatory, environmental, or end-use requirements.

Finishing

Finishing, or post-processing, is usually undertaken to provide a uniform and customized product that is acceptable and marketable to customers. Considerations include particle size, moisture content, carbon-to-nitrogen ratio, color, texture, removal of contaminants, and nutrient and bacterial content. Finishing can include screening, blending, introducing additional nutrients and bacteria, drying, and bagging. The most common finishing practice is screening, which can significantly improve the value and quality of compost to be distributed. Screening can improve the appearance, texture, nutrient content, and carbon-to-nitrogen ratio of the compost, as well as remove unwanted materials. Screening also creates fractions for specific end uses.

The economics of finishing also should be considered. The costs of finishing should be evaluated along with the value and demand for the product.

Storage

Maintaining some inventory of finished compost products is usually inevitable. Storage of compost materials may also be accomplished throughout the curing, finishing, and distribution processes. Storage of materials can be under-cover, in containers, or outside. Under-cover and container storage will help prevent the effect of weather conditions on materials. Container storage will also allow the potential for control of odors, if necessary. Outside storage is usually the least costly but can be the most problematic. Outside storage considerations include the type of storage pad, stormwater

CHAPTER 6: HOW TO PRODUCE HIGH QUALITY COMPOST

COMPOST USE IN FLORIDA

COMPOST USE IN FLORIDA
The Effects of Compost on Soil

When used as a soil amendment, compost can improve soil quality, help conserve water, and may reduce the need for fertilizers and pesticides.

When used in sufficient amounts, compost has both an immediate and long-term positive impact on soil properties. Compost products provide a more stabilized form of organic matter than raw wastes and can improve such physical properties as water-holding capacity, water infiltration, water content, aeration and permeability, soil aggregation and rooting depth. Compost products also decrease soil crusting, bulk density, runoff, and erosion. The chemical properties of soils that have been treated with compost are often improved, as well, as are soil biological activities.

Water-Holding Capacity

The application of compost products can markedly increase the water-holding capacity of soils. The increase is attributed to improved pore size distribution (Pagliai et al., 1981). Pores in the range of 3.5–50 micrometers (mm), called storage pores, hold water necessary for growth of plants and microorganisms.

Most mineral soils used for an agricultural purpose should receive compost rates of 10 to 15 tons/acre to increase water-holding capacity by five to 10 percent. When 146 tons/acre of MSW compost was applied, the water-holding capacity increased by 43 percent (McConnell et al., 1993). In Gallacher’s usage of compost in a corn crop, the compost treatment increased soil water storage by an amount equivalent to two acre-inches of rainfall or irrigation (Gallacher and McSorley, 1994).

In sandy soils of Florida with low water retention, both the frequency of irrigation in agricultural farms and energy consumption resulting from water pumping should decrease as a result of compost application.

Soil Bulk Density

The use of heavy equipment for crop planting and harvesting increases soil bulk density of agricultural soils due to compaction. This causes limitation of pore spaces, which decreases the aeration and water-holding capacity of soils. The incorporation of compost products in compacted soils, on the other hand, decreases bulk density and increases pore volume, the rate of water infiltration and the volume of air in the soil medium (McConnell et al., 1993). The reduction in bulk density of mineral soils depends on the rates of compost application, the soil type, and the degree of soil compaction.

Soil Erosion

Compost plays an important role in control of erosion by both water and wind. The degree of soil erosion by water depends on the strength of soil aggregates to withstand raindrop impact and surface flow. Composts with high organic matter content perform well for controlling erosion by water.

For controlling wind erosion, long-term research has shown that use of normal-size MSW compost is more effective than the very fine variety. Small particle size and lightweight compost products are susceptible to wind erosion under arid conditions.

Soil pH

Soil pH affects the availability and absorption of nutrients by plants, particularly micronutrients. Most compost products have a near neutral or slightly alkaline pH with a high buffering capacity. Elevation of pH by compost application can bring about strong absorption of and, in some cases, precipitation of cadmium (Cd), manganese (Mn), lead (Pb), and zinc (Zn) in soil particles, resulting in lower accumulations of these elements in plant tissues.

Most agronomic crops grow well when the soil pH is between 6.0 and 7.0. Addition of compost
to acid soils and subsequent pH elevation reduces or eliminates aluminium (Al) or manganese (Mn) toxicity, which can occur when soil pH is below 5.5 (Hernando et al., 1989).

The change in pH values of mineral soils by compost application depends upon the composted material and the initial soil pH and the soil’s buffering capacity. Incorporation of compost at rates of 10 to 20 tons/acre usually increases pH by 0.5 to 1.0 pH unit in acid soils (Hernando et al., 1989).

Cation-Exchange Capacity

Cation-exchange capacity (CEC) is the sum total exchangeable cations that soil can absorb. Cation-exchange capacity of soils is important in retaining nutrients against leaching by irrigation water or rainfall. Sandy soils tend to show the greatest increase in CEC by compost application. In a Florida sandy soil, a compost application rate of 15 tons/acre increased CEC by about 10% (Hortenstine and Rothwell, 1973). High rates of compost application (more than 10 tons/acre) increased soil CEC, while low rates (less than 10 tons/acre) did not change or had minimal effect on CEC. Research results indicate that application rates of 15 to 30 tons/acre would increase the CEC of most mineral soils used for agricultural purposes by a minimum of 10% (McConnell et al., 1993).

Nutrient Content

Although compost products contain a considerable quantity of macro and microelements, the nutrient content of compost products is lower than commonly used chemical fertilizers. And although nitrogen (N) and phosphorus (P) contents of compost are higher than most agricultural soils, the availabilities of these nutrients are low. One reason is that release of nitrogen from an organic source such as compost is in a mineral form that is unavailable to plant roots. Compost nitrogen is a valuable slow released nitrogen source. The rate of microbial mineralization and release of available nitrogen from structural forms in the compost depend on the local climate and the soil type. The first year rate may vary from 5% to more than 75% (Sommer and Giordano, 1984).

Because of the warm and humid climate and sandy soils in Florida, the rate of nitrogen mineralization is very high; therefore, plant response to compost nitrogen is much quicker than in cold regions of the U.S., such as the northeast, with lower annual rainfall and heavier soils. Incorporation of compost types with high carbon-to-nitrogen ratios will elevate the carbon-to-nitrogen ratios of soils. A soil carbon-to-nitrogen ratio above 30 causes nitrogen immobilization, or nitrogen-rob, and nitrogen deficiency in plants. Nitrogen-rob occurs when microorganisms consume the available plant nitrogen in the soil in order to decompose the compost. Application of nitrogen as a mineral fertilizer usually corrects this type of nitrogen deficiency. Alternatively, if cropping can be delayed a few months, the compost will stabilize in the soil, correcting the problem. Application of compost as a soil amendment reduces nitrogen leaching from soil. Therefore, utilization of compost as a soil amendment could reduce the amount of commercial nitrogen fertilizer applied and decrease the possibility of nitrate groundwater contamination (Shiralipour et al., 1992b).

The nitrogen content of a composted product depends on the feedstock and processing technology used to produce the compost. The nitrogen-phosphorus-potassium (N-P-K) ratio of most composted MSW is such that application to soils at a rate selected to satisfy the nitrogen needs of a crop might result in excess additions of phosphorus and insufficient levels of potassium. Consequently, the use of supplemental fertilizers may be required to bring the nutrient levels in balance with crop demand. As with all fertilization practices, the amounts of nitrogen, phosphorus and potassium required for crop production are best determined by soil testing.

The quantity of other macro and microelements in compost products depends on the feedstock’s type and origin and the method of compost production. Their availability is also controlled by mineralization or compost decomposition rate. Nevertheless, keep in mind that composts are seldom used as fertilizer but as an overall soil conditioner.

Soil Microorganisms

The activity of soil microorganisms is affected by compost application. Microorganisms play an important role in decomposition of soil organic matter, which leads to formation of humus and available plant nutrients. An increase in soil organic matter content through compost application can promote root activity, as specific fungi function symbiotically with roots, assisting them in the extraction of nutrients from soils.

Earthworms

The population of earthworms is also increased by the addition of sufficient levels of compost products. The soil movements and tunneling by the earthworms results in enhanced aeration and water infiltration.

Soil-Borne Plant Pathogens

Application of compost has been advocated by “organic” farmers for many years as a way to reduce or eliminate the use of pesticides and soil fumigants. Indeed, suppression of soil-borne plant pathogens by composts has been well documented by some investigators (Ezizink et al., 1993). This occurs through a phenomenon known as antagonism or amelioration. Microorganisms that produce substances toxic to competing populations will naturally have a competitive advantage. For example, a species of bacteria commonly found in compost produces antifungal volatiles (Fiddaman and Rossal, 1993). Hotink et al. (1993) have shown that wood waste compost was at least as effective as fungicides in controlling Phytophthora root rot. In such cases, it appears that composts increase host vigor and their ability to resist infection by pathogens. Thus, compost application can eliminate or reduce the use of pesticides.
PART 3: AGRICULTURAL USES FOR COMPOST IN FLORIDA

CHAPTER 8

The Benefits of MSW Composts in South Florida

Compost use offers an economical way to enrich the nutrient-poor soils of South Florida.

South Florida has a combination of geographical and environmental conditions that make it unique to the continental United States. Because South Florida is situated on a formerly submerged coral shelf, there is very little naturally occurring topsoil. In addition, the region's subtropical environment ensures a constant, rapid, and continuous degradation of any naturally occurring organic material. With the exception of the Everglades agricultural region, this has prevented any accumulation of rich soils preferred by agricultural producers. However, plenty of warmth, sunlight, and water help compensate for the lack of rich soils. Through the addition of relatively large amounts of fertilizers, pesticides, fungicides, and herbicides, bountiful good quality crops, including vegetables, tree crops, ornamentals, turf, and landscape materials, can be grown successfully.

Researchers are now discovering that the addition of composts, especially municipal solid waste composts, can be particularly beneficial in this region.

Using MSW Compost in South Florida

During the 1992–1993 crop year, approximately 20,000 tons of Second Nature MSW compost, produced by Reuter Recycling of Florida, was distributed over 315 acres of South Florida farmlands distributed from Florida City to Boca Raton. Two different compost rates (20 and 40 tons per acre, plus a control rate of 0 tons) were applied at four different locations, with diverse soil types, ranging from sandy to rocky, that produced a variety of crops, including beans, eggplant, peppers, tomatoes, squash, zucchini, herbs, and others. In the compost test areas, average crop yield increases of between 28% and 44% were experienced in controlled, large-scale research plots in the fields. Results also demonstrated increased nutrients, decreased crop water requirements, nematode and pathogen suppression, a reduction of the impact of crop production on groundwater supplies, and a reduction in weed populations in compost-amended areas. There were also indications of possible pest suppression in compost-treated areas.

While the crop responses to the compost applications were crop-specific, a general trend toward larger plants was observed for most crops. There were also carry-over crop benefits seen during the following season, with indications of further carry-over through to the third season. Further, the reduction in chemical dependency for crop production will favorably impact both the farmer and the environment in the near future. All of these observations are consistent with results recorded throughout the history of compost production, of the benefits of amending native soils with composts.

South Florida is also home to one of the largest ornamental plant production areas in the United States. Tremendous amounts of potting soils and topsoils used in landscaping and container production are consumed in South Florida each year. One of the basic components of potting soils is peat moss. The major topsoil component used for landscaping is muck, a highly degraded form of naturally occurring sedge peat, found in limited areas of Florida. The normal function of this material in nature is as a natural water filtration medium that cleanses surface water as it percolates through the ground into the underground aquifers that make up our groundwater.

Removal of this sedge peat or muck surface substrate for usage as a potting media or topsoil effectively removes a like amount of natural water purification capability, thus reducing the water quality as well as the amount of clean water available for public consumption. Finding a suitable substitute for the muck and sedge peat fractions of potting media and topsoils is a critical task. It is becoming increasingly clear that MSW composts appear to have the ability to act as substitute.

Research ongoing at the University of Florida has clearly demonstrated the ability of MSW compost to replace peat moss one-for-one in potting soils. Demonstration projects at a number of different commercial nurseries verified the study results. Landscape topsoil production using MSW composts as one of the major components proved to be a successful commercial endeavor, with the end product having already been successfully used on numerous landscape projects. Project expansions into turf production and public works are also planned.
How Compost Benefits Citrus Crops

Applying compost to Florida citrus trees may reduce disease, stimulate tree growth and increase crop yield.

J. H. GRAHAM
UNIVERSITY OF FLORIDA
CITRUS RESEARCH AND EDUCATION CENTER
LAKE ALFRED, FLORIDA

Citrus is the most economically important and widely planted crop in Florida, covering about 675,000 acres in Central and South Florida. Between 1992 and 1994, more than 10.3 million new trees were planted on sandy soils, mostly low in organic matter, and poor in nutrient exchange and water-holding capacity. Recent studies have demonstrated that composted municipal solid waste (CSMW) and composted urban plant debris (CUPD) are beneficial to citrus, reducing the incidence of root infection, stimulating growth of young trees, and increasing yield and fruit size in Central Florida citrus groves.

The center of the citrus industry is within a 100-mile radius of a densely populated area of the state, where more than 7 million people produce 1 kg of solid waste per person per day, one that holds the potential for providing the citrus industry with low-cost compost.

Potential Uses of Compost in Citrus Groves

Florida nurseries, raising concerns about the long-term usage of this fungicide in citrus groves (Timmer et al., 1998). An alternative strategy to fungicides for controlled soil-borne diseases is to periodically apply composted organic materials as amendments to suppress fungal root pathogens. Composted bark, when incorporated into potting media, suppresses soil-borne diseases of ornamental plants (Hoitink and Grebus, 1994). In Australian avocado groves, root rot caused by P. cinnamomi has been effectively controlled by intensive mulching with organic amendments and applications of gypsum (Broadbent and Baker, 1974). In our studies of citrus, composted waste from different sources reduced the incidence of root infection of citrus seedlings through direct suppression of P. nicotianae in soil (Widmer et al., 1998a). We conducted greenhouse and field studies to examine the potential for compost to suppress P. nicotianae and improve root health.

Responses of Young Trees to Composted Municipal Waste

Three trials from 1991 to 1996 demonstrated that mulch treatments of compost are highly effective for growth stimulation of young citrus trees in newly established groves (Widmer et al., 1996,1999b). Responses were seen for soils typical of both the ridge and flatland production areas. While greenhouse bioassays predicted that compost might suppress the pathogen (Widmer et al., 1998a), populations of P. nicotianae were either not affected or even increased by compost. Despite pathogen activity in compost-amended soils, the trees performed nearly as well as those in nonamended soils and significantly better than those in nonamended soils. Stem diameter and root mass of young trees increased 20-30% in response to post-plant treatments with surface mulches as well as incorporation treatments at planting. The growth response is best explained by increased tolerance to the disease rather than pathogen suppression. Tolerance is attributed to improved conditions in the root zone for more efficient water and nutrient uptake.

Operationally, the CSMW and CUPD is most effectively and efficiently applied with a New Holland 3000 side-discharge spreader as a 5- to 10-cm thick mulch layer within the tree row to cover about 80% of the root system. The application rates are quite high, ranging from 150-170 metric tons per hectare, the mulch lasts up to 2 years before reaplication is necessary. Reduction of mulch layers to 2-3 cm thick decreased the tree response and may require yearly reaplication to be effective. Current trials are designed to establish the optimum rate of CSMW and CUPD and the mechanism for the growth enhancement of young citrus in low organic matter sandy soils. Youngridg showed adequate fertilizer and scheduled irrigation so compost did not substantially increase their nutrient assimilation rates, due to their moderate high carbon-to-nitrogen ratios.
Observations of Composted Municipal Wastes on Florida Citrus

Andrew S. Prior
Sun-Ray and Southern Farms
Lake Place, Florida

Sun-Ray and Southern Farms are citrus grove operations of 9,000 acres in Highlands County, Florida. During the past five years, composted wastes have been applied to "sand soil" areas — sandy soils low in organic matter and poor exchange capacity. The following are some of the observations from these applications.

Timing
These materials are best applied during a period with frequent rainfall. The summer period, particularly the month of August, is best. When compost is applied during a wet period, a far better result is acquired.

Products
We have applied municipal wastes composted with biosolids, urban plant debris composted with biosolids, wood mulch composted with biosolids, and various forms of composted chicken manure. The composted wood mulch with biosolids proved to be the most consistent, and the tree response was longer lasting. Chicken manure proved to be a good short term green-up to carry the trees through stress.

Placement
Applications in the tree row seem to give better response than applications trunk to trunk across the bed. The tree row application should be at a rate of at least two tons per acre.

Economics
A consistent compost product is required to enable an efficient application. Sufficient benefit can be achieved if the compost product can be applied under the tree for less than $30 per ton.

and probably other soil stresses as well.

Current Status of Research on Citrus
Some limitations in the use of compost have been encountered. Foremost is the high quality source of compost was the citrus industry that can be supplied with minimal delivery cost. Most of the research has been conducted with a co-composted municipal solid waste (approx. 90%) with waste water residuals (10%) from Sevierville, Tennessee, supplied by Bedminster Bioconversion. Co-composted CMW has a favorable carbon-to-nitrogen ratio (19:1) and slow rate of N mineralization (Eichelberger 1994), so nitrogen leaching is not a concern. The local CMW (Reuter) tested in the early 1990s is no longer available because the plant shut down. Evaluation of CUPD from another source has only recently been initiated. A grower/cooperator conducted a preliminary trial with CUPD in 1996 and reported that the material was very fibrous, containing pale branch wastes and other coarse woody residuals that made spreading difficult. The CUPD material also may have been high in salts. Thus far, residual salts in the Bedminster CMSW have not been a problem for citrus, due to the very sandy soils that facilitate rapid leaching of salts and to the long-term nature of the response on preemergent citrus trees (at least one year to detect growth responses). The CUPD material spread in 1997 did not share the problems experienced with the 1996 material, but this points out the need for compost to be consistent in quality through time if they are to be used commercially.

Another major limitation to proceeding with further trials is the availability of a commercial applicator with the New Holland equivalent spreader in south-central Florida. Two cooperators representing about 25,000 acres of commercial grove land are at present unable to use compost because they are unwilling to purchase a spreader, given the high capital cost (approximately $10,000-14,000) and the uncertain availability of high quality compost. Nevertheless, our results have stimulated their interest in further trials of local compost sources, especially in sandy soils with low organic matter.

Our current evaluation of the benefits of compost used as mulches focuses on both young and old groves in sand soil soils where citrus trees have not responded to extra water and nutrients inputs and, thus, probably are not manageable without soil amendments. Reduced rates of compost produced by local municipalities in close proximity to the citrus industry are now under evaluation to further quantify the benefits and costs of compost applications. Although the responses are positive, it is unlikely that the horticultural benefits will offset the high cost of production and transport of compost. However, if landfill space becomes a problem in the future, the cost of production and transport of compost eventually may be borne by the municipalities. For example, Los Angeles County now pays citrus growers to accept urban plant debris for use in their citrus groves (J. A. Menge, University of California, Riverside, personal communication).
Growing Field Crops with Compost

The use of urban plant debris compost can increase crop yield and decrease forage cost production.

R.N. GALLAHER
DEPARTMENT OF AGRICULTURE
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

n Florida, tropical corn is better adapted to local soils than conventional corn varieties usually developed for the midwest. Tropical corn acreage in the southern United States increased from about 1,700 acres in 1985 to approximately 45,000 acres in 1991. Recent estimates indicate a potential of 150,000 to 200,000 acres of tropical corn with the primary use as a late season planted silage crop. Sorghum [Sorghum bicolor (L.) Moench] is another valuable silage crop that is adapted to late sowing conditions. In Florida, about 18% of the 142,000 acres of Fall-sown tropical corn and 58% of the 42,000 acres of double-crop corn is grown with conservation tillage management. A significant acreage of soybean [Glycine max (L.) Merr.], cotton (Gossypium hirsutum L.), small grains, forages and other crops, such as vegetables, peanut (Arachis hypogaea L.), tobacco (Nicotiana tabacum L.), etc., are also grown on Florida's Fall-sown and highly leachable sandy soils.

Land on which these crops are grown offers an opportunity to reestablish soil structure. Tropical corn, for example, is a very deep-rooting crop, and the nutrients thus can be deep rooted in the soil profile, allowing for greater nutrient availability over time. As a result, the use of compost as a soil amendment can be very beneficial for these types of crops.

Impact of UPD Compost on Soil Properties

Large applications of UPD can have a major impact on improvement in soil quality, often associated with a positive crop response. For example, in a study conducted by Gallaher and McSorley, 1995a, it was observed that the use of composted manure resulted in increased rates of phosphorus and potassium uptake by plants. This is likely due to the increased organic matter content in the soil, which provides a reservoir of nutrients for plant uptake.

Soil nutrients. The UPD used in the study had a carbon:nitrogen (C:N) ratio of approximately 35:1 (Gallaher and McSorley, 1995a). In order to alleviate nitrogen-rob (N-rob) of crops, the compost needs to be incorporated into the soil a minimum of 3.5 to 4 months before planting to allow equalization to occur (D.A. Graetz, Soil and Water Conservation Service, University of Florida, personal communication). Nitrogen-rob does not appear to be a major problem when the UPD is used as a mulch and the required addition of nitrogen fertilizer is placed below the mulch (Gallaher and McSorley, 1995a).

Long-term effects. All of the soil properties, including organic matter, nitrogen, and cation-exchange capacity, were dramatically increased from application of UPD the magnitude of which was highly correlated with the amount of UPD applied. Organic matter reached a peak in the third year after UPD application and seemed to be maintained for the next two years at the highest UPD rates. Soil nitrogen appeared to peak one year after the last application of large amounts of UPD. Extractable nutrients were also increased by application of UPD (data not shown). Data seemed to fluctuate somewhat for phosphorus, perhaps as a result of more than one mechanism, such as faster fertilization, soil fixation versus extractable, and crop uptake. It is clear that large quantities of phosphorus were applied in UPD.

Extractable calcium peaked the year of the last application of UPD then declined. This may be consistent with what would be expected, since large quantities of calcium are taken up by a corn crop, potassium is highly leachable in a sandy soil, and it is somewhat replaceable on exchange sites even though, in this case, the cation-exchange capacity had increased. Extractable calcium and magnesium appeared to peak and be maintained, with the case of calcium, may have even increased after the last year of UPD applications. The cation-exchange capacity seemed to peak one year after the last application of large amounts of UPD. Continued soil analyses of these plots for future years would be useful in determining the duration of the impact that UPD has on continuing changes in soil variables.

Compost Effects on Nematodes

The increased nutrient levels and water-holding capacity of soils amended with compost may increase soil tolerance to nematode damage (Waston, 1945).

There is evidence that the addition of certain organic compost compounds may stimulate fungal parasitism of nematodes (Rodriguez-Kabana, 1991). However, most important effect of organic amendments on plant-parasitic nematodes may be the reduction of populations from toxic byproducts of decomposition. Ammonia and urea were shown to suppress several nematode species in tests, and the decomposition of some forms of organic nitrogen can release byproducts which are toxic to nematodes (Rodriguez-Kabana, 1986). The most effective of these amendments are those with low carbon-to-nitrogen ratios that can release ammonia into the soil (Rodriguez-Kabana, 1986).

Regardless of the mechanism involved, the addition of organic amendments may serve to alleviate some of the adverse effects on crop growth caused by plant-parasitic nematodes. Of the plant-parasitic nematodes found at some UPD Florida field research sites, Panagrellus redivivus was significantly decreased from application of UPD (McSorley and Gallaher, 1996). Other nematodes, such as Pratylenchus penetrans, were not consistently affected by compost applications. Effects of the high carbon-to-nitrogen-ratio compost on these agricultural sites may provide beneficial effects only after several years of UPD application.

In another study, transplanted seedlings of squash (Cucurbita pepo) and okra (Hibiscus esculentus) and the use of conventional tillage incorporated UPD to appear to result in best yields (Gallaher and McSorley, 1995b). These results were based on limited data and a limited number of soil properties to be impacted by compost and to translate into positive crop response. Total different results may be found between conventional tillage versus no-tillage, and soil properties have been enhanced from use of UPD. From this study, it was concluded that the main benefit of UPD against nematodes did not appear to be reduction of nematode populations, but improved growth and tolerance of crops in nematode-infested sites. Sweet corn yields were equal for UPD treatments both conventional tillage-incorporated and no-tillage-mulch, and both gave yields superior to the conventional tillage control without UPD (Gallaher and McSorley, 1995b).

Response of Corn to UPD Compost

There was a consistent trend for corn forage yields to increase as the cumulative total UPD application rate increased. A high correlation was found between corn forage yield (Table 10-1) and all of the soil property variables presented. These data also show that the effects of UPD application, at the high rates used in these studies, had a long-term benefit on soil quality and crop yield, extending well beyond the last year of UPD application (1994). In future research, three. terms determined how long these benefits will persist.

Increased corn forage yields from use of UPD ranged from 2.5 ton/acre to 6 ton/acre, valued at $34/ton (based on 30% dry matter) depending on the experiment. Increased yield was positively correlated with the increased soil organic matter, improved soil fertility conditions, and greatly increased soil water storage capacity. Mulched no-tillage UPD treatments consistently had greater amounts of stored soil water compared to the conventional tillage incorporated UPD treatments (Gallaher and McSorley, 1994).
Florida is a major vegetable-producing state, with 418,000 acres under cultivation each year (Florida Agricultural Statistics Services, 1997). Sandy soils used to grow Florida vegetables have low native fertility, so they require relatively high fertilizer inputs. However, minimizing fertilizer leaching or runoff has become important as a result of potential negative environmental impacts. If water and fertilizer conservation could be increased, grower input costs and negative environmental effects could potentially decrease.

In recent years, composts produced from a wide range of waste materials have become available in Florida on a large scale (Smith, 1992). While environmental regulators are mainly concerned about trace metal concentrations in compost, growers have different interests once compost has passed regulatory health and safety standards (Ozes-Hampton et al., 1998a). From a commercial vegetable grower’s point of view, compost quality is judged by its moisture and nutrient concentration, pH, soluble salts, organic matter concentration, carbon-to-nitrogen (C:N) ratio, water-holding capacity, bulk density, cation-exchange capacity, particle size, presence of weed seeds, and odor (Ozes-Hampton, et al. 1998a).

Pros and Cons of Applying Compost to Vegetable Crops

When compost is incorporated into soil, observed benefits to crop production have been attributed to improved soil physical properties. Compost usually contains large quantities of plant-available micronutrients (Ozes-Hampton et al., 1998a). However, soil improvements are mainly produced to attributed increased organic matter concentration rather than increased nutrient availability. (Gallardo-Lara and Nogales, 1987). Significant quantities of nutrients (particularly nitrogen, phosphorus, potassium, and micronutrients) become bioavailable with time as compost decomposes in the soil. Amending soil with compost provides a slow-release source of nutrients, as opposed to mineral fertilizer, which is usually water-soluble and is immediately available to plants. Crop injury has been linked to use of poor-quality compost, such as that from early stages of the composting process (Zucconi et al., 1998a). The type and degree of plant injury is directly related to compost maturity and soluble salt content. Optimum chemical and physical parameters for composts that might be used in vegetable crop production are listed in Table 11.

In Florida, soil application of immature compost consistently resulted in "N-immobilization," where available forms of inorganic N were converted to unavailable organic N followed by growth inhibition of vegetable crops such as beans, corn, peppers, tomatoes, and squash (Kostewicz, 1993; Gallaher and McSorley, 1994; Bryan et al., 1995). When immature compost is applied and a crop is planted immediately, growth inhibition and stunting may be visible for 40 to 60 days. When using compost with C:N ratios higher than 25 or 30, N fertilizer should be applied, or planting delayed to 6 to 10 weeks to allow the compost to stabilize in the soil (Ozea and Reeder, 1994).

Research on vegetable compost utilization in Florida has established several potential applications: soil amendments, soil-borne disease suppression, biological weed control, alternative to polyethylene mulch, and as a transplant media.
TABLE 11-2
Physical properties of compost used in vegetable production.*

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Optimal Range</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>35-55</td>
<td>Higher moisture, increased handling/transportation costs</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>50 or more</td>
<td>Higher organic matter lowers application rate</td>
</tr>
<tr>
<td>pH</td>
<td>5.0-8.0</td>
<td>In neutral to alkaline compost will raise pH</td>
</tr>
<tr>
<td>Water holding capacity (WHC) (%)</td>
<td>20-40</td>
<td>Higher WHC leads to lower irrigation frequency</td>
</tr>
<tr>
<td>Soluble salts (dS/m)</td>
<td>less than 6.0</td>
<td>Higher than 6.0 means potential toxicity</td>
</tr>
<tr>
<td>Bulk density (lb/ft^3 x depth, weight)</td>
<td>500-1000</td>
<td>Higher moisture content means a greater bulk density</td>
</tr>
<tr>
<td>Particle size</td>
<td>Passes 1 inch screen</td>
<td>Increase soil porosity</td>
</tr>
<tr>
<td>C:N ratio</td>
<td>15-28</td>
<td>Higher C:N ratio means &quot;N immobilization&quot;</td>
</tr>
<tr>
<td>Maturity (G.I.1)</td>
<td>Over 60</td>
<td>GI lower than 60 indicates phytotoxicity</td>
</tr>
<tr>
<td>Crumb stability</td>
<td>Stable</td>
<td>Insolubility can cause &quot;N immobilization&quot;</td>
</tr>
<tr>
<td>Weed seeds</td>
<td>None</td>
<td>Uncomposted materials disseminate weeds</td>
</tr>
</tbody>
</table>

* GI = % seed germination a root growth of 10 in. of control/100.

Compost as a Soil Amendment

Amending Florida soils with composted materials such as biosolids, MSW, and urban plant debris (UPD) has been reported to increase crop yields of bean, black-eyed pea, okra, tomato, squash, eggplant, and bean, watermelon and tomato, corn, and bell pepper (Bryan and Lance, 1991; Ozes-Hampton and Bryan, 1993a, 1993b; Ozes-Hampton et al., 1994b; Obreza and Reeder, 1994; Gallaher and McSorley, 1994). In calcareous soil, application rates of biosolids compost as low as 3 to 6 tons/acre resulted in crop yield increases for tomatoes, squash, and beans (Bryan and Lance, 1991; Ozes-Hampton et al., 1994b). In sandy and calcareous soil, MSW compost application rates of 40 tons/acre resulted in crop yield increases for bean (Obreza and Reeder, 1994). (Figure 11-1) Contradictory crop response results were found when a compost with low nutrient content was compared to a traditional fertilizer program. However, combining such compost and inorganic fertilizer has generally been more effective in producing a positive plant response than separate application of either material alone. One concern of using biosolids or MSW-based composts is the possible presence of unwanted elements in the compost and their uptake by plants. Compost that does not meet EPA 503 standards for metals concentration in biosolids cannot be marketed and is thus unavailable to be applied to agricultural land. Research in Florida on tomatoes and squash grown on calcareous soil where biosolids, MSW, and co-composted biosolids-MSW that met the 503 standards were applied showed no trace metal accumulation in the edible plant parts (Ozes-Hampton et al., 1994b and 1997). If all of Florida’s organic fraction of solid waste was converted to compost, it could easily be assimilated by the Florida vegetable industry. If only 20 tons/acre of compost (fresh weight) were applied to each of the 418,000 acres of vegetables annually grown in Florida, 8.4 million tons of compost could be recycled each year (Smith, 1994). The actual rate and frequency of compost use should be determined by compost properties such as nutrient concentration or N mineralization rate, and soil physical and chemical properties.

Soil-borne Disease Suppression

The colonization of compost by beneficial microorganisms during the latter stages of composting appears to be responsible for reducing disease suppression. Compost does not kill the pathogens that cause disease as fungicides do. Instead, compost controls the pathogens by keeping the beneficial microorganisms active and growing. Therefore, pathogenic agents either will not germinate or will remain inactive (Ozes-Hampton et al., 1994a).

In Florida, few experiments in vegetable crop production under field conditions have investigated the use of compost in controlling soil-borne pathogens. Municipal solid waste (MSW) was incorporated into calcareous soil in Dade County at 36 and 72 tons/acre and composted for a total control 36 and 72 tons/acre (Ozes-Hampton et al., 1994a). A two-crop rotation of bush beans and southern peas was seeded. Bean emergence and yield were improved by 25% in the compost treatment compared to the untreated control. As the stem blight of bean caused by Macrophomina phaseolina was severe in areas with no compost application, but was almost completely eliminated where MSW compost had been applied (Figure 11-2). MSW compost reduced the damage by Xanthomonas root rot in southern pea considerably compared with the untreated control. In the areas with no compost application, severe infections caused plant stunting and premature death, with significant yield reduction.

Biological Weed Control

Weed growth suppression is an important attribute of surface-applied mulch. An organic mulch suppresses weeds by its physical presence as a surface cover, or by the action of phytotoxic compounds contained in it (Ozes-Hampton et al., 1998b). Weed seed germination inhibition by burial under mulch is due to the lack of growth-promoting factors such as light, temperature, or moisture. Chemical effects of phytotoxic compounds (volatile fatty acids and/or ammonia) in compost can decrease weed seed germination. In Florida, a water extract of 3-week-old UPD and immature MSW compost decreased germination of several perennial and annual weeds in petri dishes (Shiralipour et al., 1991). Under field conditions, application of immature 4-week-old MSW compost at 3 inches (45 tons/acre) or greater thickness completely inhibited weed germination and growth for 240 days after treatment in vegetable crop row middles. Inhibition of germination or subsequent weed growth may be attributed to both the physical effect of the mulch and the presence of phytotoxic compounds (fatty acids) in the immature compost (Ozes-Hampton et al., 1998b).

Figure 11-1: MSW compost application rates of 40 tons/acre (top) as compared with the no compost application (bottom) on watermelon. Compost-treated plots yielded 22.35 tons/acre compared with 16.15 tons/acre in control plots with no compost.

Figure 11-2: MSW compost application rates of 72 tons/acre (front) nearly eliminated ashy stem blight, compared with the no compost application (back) on bush beans.
Compost as a Transplant Medium

The vegetable transplant industry relies on peat moss as a major ingredient in soilless media (Varrina and Summerhill, 1992). Peat is an expensive, non-renewable resource. In Florida, alternative soilless media has been investigated to grow tomato, cucumber, bell pepper, and citrus seedlings (Varrina, 1994; Ray and Kontiwicz, 1992; Stoffella et al., 1996). Seed emergence and seedling growth was similar to traditional peat-vermiculite media when peat was partially replaced with compost. Negative growth effects were reported when the medium was 100% compost, especially when immature, unstable compost was used or the compost did not have adequate fiber content to assure a desirable bulk density.

Compost for the Landscape and Nursery Industries

High quality compost frequently compares favorably with peat as a growing medium for Florida’s nursery and landscape plants.

All different agricultural uses for compost products, use as a growing medium component in ornamental crop production frequently receives high priority because of the relatively high value of nursery and greenhouse crops and the continual cultural requirement for organic matter for rooting substrates (Sivki et al., 1992; Tyler, 1993; Tyler, 1996). Every container plant is sold, the rooting substrate is sold with it, necessitating the need for new potting mixtures to start new crop production cycles.

The attractiveness of ornamental crops as outlets for compost product marketing does not come without cost, however. Since the plant’s root system is in direct and continual contact with the compost product, any concern regarding compost quality are most acute with container crops. Plant producers must keep in mind that the way compost products should be used is not necessarily the same way that natural humus products, such as peat, are used.

Using Compost for Ornamental Crop Production

Compost materials have been used successfully to grow a wide spectrum of nursery crops, from flowering annuals (Woolton et al., 1982) to container-grown tropical trees (Fitzpatrick, 1985). In a demonstration project conducted in 1979-1980 at a commercial nursery in southern Florida, a number of container-grown ornamental species grew to marketable size significantly faster than plants grown in a growing medium composed of 6 parts: 4 sand: 1 sand: 1, by volume (Fitzpatrick, 1981). One of the species tested, dwarf oleander (Nerium oleander), grown in 10-inch diameter containers for 5 months, averaged approximately 1.25 times larger when grown in the compost mixture compared to the control (Figure 12-1). Moreover, compost products have been successfully used in field nurseries as soil amendments to increase productivity in various tree species (Gouin, 1977; Gouin and Walker, 1977).

Numerous other research studies and reviews have been published on how compost products can be used to improve production of nursery crops. Sanders (1979) reviewed a large number of published studies and reported significant increases in productivity across a wide variety of nursery crops. More recently, Shiralipour et al. (1992a) reviewed published studies on compost use in a wide variety of crops, including nursery crops, and reported significant increases in crop productivity.

Unlike other applications of compost in agriculture, the stand-alone container medium nursery operation requires the highest quality of compost. One example of the influence of compost quality on compost performance as a component in a horticultural growing medium is the level of total salts in the substrate. The level of soluble salts in composts made from sludges stabilized with ferric chloride and lime may be considerably higher than those in compost made from sludge that has been stabilized using a wet-air oxidative process. One study compared the use of these two types of sludges for growing the non-salt-tolerant container crops Sparganium Mauna Loa and Schaffnera arborescis. The plants grown in the compost with higher soluble salt levels were significantly smaller than plants grown in composts with lower soluble salts. However, both compost products resulted in plants that were significantly larger than plants grown in a control medium consisting of 40% peat, 50% pine bark and 10% sand (Fitzpatrick, 1986).
Use of Compost on Turfgrasses

Compost may help build better turfgrasses on some 148,000 acres of golf courses in Florida.

There are more than 5 million homes with turfgrass lawns in Florida, and more than 1,300 golf courses, an increase of more than 15 percent since 1994. The average Florida golf course is 114 acres in size. Thus, more than 148,000 acres in Florida are dedicated to golf courses. Golf course maintenance expenditures average $3,585 per acre annually. Money generally is available and will be spent by golf courses for maintenance practices that are proven to be beneficial.

Beneficial Effects of Composts on Turfgrasses in Florida

Numerous articles recently have discussed the potential use of compost on golf courses. Most of these focus on using compost for topdressing, and some discuss the use of golf course-generated organic waste as compost feedstock. However, there is little documentation of actual compost use on golf courses, other than as mulch around ornamental plantings. The use of compost as a soil amendment during golf course construction is rarely discussed. Because of a lack of scientific studies aimed specifically at utilizing compost in golf courses in Florida, discussions on the subject will be based upon inferences from uses of composts in other turfgrass situations and from other regions. Detailed, specific, proven recommendations for compost use on golf courses in Florida cannot be given at this time.

Of the research that has been conducted on golf courses in Florida, most has related to using compost as a soil amendment to improve the native sand soils which generally are droughty, infertile, and have little capacity to retain nutrients and other agrochemicals. We have consistently demonstrated that overall turfgrass quality, in terms of visual appearance and vegetative density, is improved by the incorporation of composts in the root zone at rates up to approximately 30% by volume (Cisar and Snyder, 1995; Snyder and Cisar, 1996). In these studies, various municipal composts were spread over the soil surface at a depth of approximately two inches and incorporated by rototilling to a depth of approximately six inches.

Particularly in the months shortly following compost application, drought resistance has been observed (Cisar and Snyder, 1995). The time following a rain-fall or irrigation event until turfgrass wilting was observed to be increased in those plots that received the compost incorporation. In greenhouse studies, leaching of several organophosphorus insecticides was reduced by compost addition, and the addition of compost did not increase leaching of nitrogen or phosphorus (Cisar and Snyder, 1995).

Compost clearly provides much needed plant nutrients for turfgrass growth, which is reflected as increased uptake of nutrients by turfgrass grown in compost-amended soils (Table 13-1). In one compost source study that is still underway, the positive turfgrass growth and visual turfgrass quality effect of compost incorporation has been observable for more than 2.5 years.

We believe the major nutritional benefit of the compost is due to the quantity of nitrogen it contains, which is slowly released to the turfgrass over time. In this regard, some sources of compost contain more nitrogen than others. Those that are amended with biosolids have analyzed higher in nitrogen than composts made exclusively from urban plant debris, and turfgrass growth has been greater in soils amended with such materials (Snyder and Cisar, 1996). The composts contain other nutrients as well, but some fertilizer may be needed.
CHAPTER 13: USE OF COMPOST ON TURFGRASSES

Table 13-1: Effects of Compost on Nutrients in Turfgrasses

<table>
<thead>
<tr>
<th>Date</th>
<th>Element</th>
<th>No compost</th>
<th>With compost</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/18/67</td>
<td>N</td>
<td>31</td>
<td>35</td>
<td>ns</td>
</tr>
<tr>
<td>5/27/67</td>
<td>P</td>
<td>19</td>
<td>26</td>
<td>*</td>
</tr>
<tr>
<td>27/2/68</td>
<td>N</td>
<td>23</td>
<td>58</td>
<td>**</td>
</tr>
<tr>
<td>25/9/70</td>
<td>P</td>
<td>22</td>
<td>78</td>
<td>**</td>
</tr>
<tr>
<td>20/5/73</td>
<td>N</td>
<td>205</td>
<td>658</td>
<td></td>
</tr>
<tr>
<td>7/6/73</td>
<td>P</td>
<td>45</td>
<td>162</td>
<td>**</td>
</tr>
<tr>
<td>3/24/75</td>
<td>N</td>
<td>129</td>
<td>183</td>
<td>**</td>
</tr>
<tr>
<td>1/18/76</td>
<td>P</td>
<td>124</td>
<td>189</td>
<td>**</td>
</tr>
<tr>
<td>12/12/76</td>
<td>K</td>
<td>121</td>
<td>649</td>
<td>**</td>
</tr>
<tr>
<td>29/7/77</td>
<td>N</td>
<td>339</td>
<td>855</td>
<td>**</td>
</tr>
<tr>
<td>3/26/78</td>
<td>P</td>
<td>208</td>
<td>715</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>K</td>
<td>1693</td>
<td>3119</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>P</td>
<td>649</td>
<td>1119</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>K</td>
<td>1342</td>
<td>2811</td>
<td></td>
</tr>
</tbody>
</table>

** and * represent P<0.01,0.05, and P>0.10, respectively.

**Table 13-2: Relationship Between Turfgrass Topdressing Rates and Depth.**

<table>
<thead>
<tr>
<th>Application rate</th>
<th>Application depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/5/100 0.0</td>
<td>inches</td>
</tr>
<tr>
<td>0.0</td>
<td>0.15</td>
</tr>
<tr>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>0.2</td>
<td>0.07</td>
</tr>
<tr>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>0.4</td>
<td>0.13</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Table 13-3: Use of Compost on Golf Courses.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Element</th>
<th>No compost</th>
<th>With compost</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/18/67</td>
<td>N</td>
<td>31</td>
<td>35</td>
<td>ns</td>
</tr>
<tr>
<td>5/27/67</td>
<td>P</td>
<td>19</td>
<td>26</td>
<td>*</td>
</tr>
<tr>
<td>27/2/68</td>
<td>N</td>
<td>23</td>
<td>58</td>
<td>**</td>
</tr>
<tr>
<td>25/9/70</td>
<td>P</td>
<td>22</td>
<td>78</td>
<td>**</td>
</tr>
<tr>
<td>20/5/73</td>
<td>N</td>
<td>205</td>
<td>658</td>
<td></td>
</tr>
<tr>
<td>7/6/73</td>
<td>P</td>
<td>45</td>
<td>162</td>
<td>**</td>
</tr>
<tr>
<td>3/24/75</td>
<td>N</td>
<td>129</td>
<td>183</td>
<td>**</td>
</tr>
<tr>
<td>1/18/76</td>
<td>P</td>
<td>124</td>
<td>189</td>
<td>**</td>
</tr>
<tr>
<td>12/12/76</td>
<td>K</td>
<td>121</td>
<td>649</td>
<td>**</td>
</tr>
<tr>
<td>29/7/77</td>
<td>N</td>
<td>339</td>
<td>855</td>
<td>**</td>
</tr>
<tr>
<td>3/26/78</td>
<td>P</td>
<td>208</td>
<td>715</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>K</td>
<td>1693</td>
<td>3119</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>P</td>
<td>649</td>
<td>1119</td>
<td></td>
</tr>
<tr>
<td>3/28/80</td>
<td>K</td>
<td>1342</td>
<td>2811</td>
<td></td>
</tr>
</tbody>
</table>

**and * represent P<0.01,0.05, and P>0.10, respectively.

**Composting Golf Course Wastes.**

Using golf course leaf blade clippings and other plant-derived materials as an organic amendment to topdressing has been an "in-house" practice of some superintendents for a number of years. However, there has been little scientific study to base recommendations for using these materials. Potential problems arising with incorporating organic matter from such sources include introduction of pathogens, weeds, nutrient-robbing from poorly composted materials, source inconsistency, and play interception from poorly sized organic materials. Golf courses may also be limited by low storage capacity and availability of composted topdressing and labor support to adequately prepare the topdressing materials. Companies that could conduct the composting operation at the golf course, and vendors who could supply composted topdressing, as needed, could fill this marketplace niche (Ostmeyer, 1993).

For golf courses that want to do on-site preparation of composted topdressings, few guidelines exist. The dry soil topdressing mix should be sieved to remove large objects and to ensure fulfillment to kill off pathogens, weed seeds, and undesirable weed propagates (Beard, 1982). The organic matter fraction portion should be sized to avoid segregation after application to the turf surface. According to Beard (1982), the final preparatory step for the topdressing mix should be conditioned for a period of up to eight to ten months to regenerate soil flora and fauna. Composted topdressing should be stored in a well-ventilated shed and be sufficiently dry at the time of application (Beard, 1982).
Compost Use on Forest Lands

Using compost on Florida's forest lands may be an acceptable means of recycling organic residuals.

H. RIEKERK
DEPARTMENT OF FOREST RESOURCES AND CONSERVATION
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

The recycling of composted residuals through forest lands is generally beneficial because of increased growth of timber with a low health risk for the remote human food-chain. Composted waste utilization on forest lands has been documented nationwide and in Florida as an acceptable alternative for waste recycling (Cole et al., 1986; Riekerk, 1986; Jokela et al., 1990). Recycling the slow-release materials carefully and sparingly on the highly absorptive porous forest soils maintains acceptable ecological conditions and runoff water quality. The added organic matter increases the absorptive capacity and decreases the acidity of Florida's forest soils. These processes, in turn, increase the retention of heavy metals against leaching into the water table (Fiskell and Pritchett, 1979).

Compost Utilization in a Slash Pine Plantation Forest

This project built upon a previous study of the benefits of compost application to a slash pine flatwoods site prior to planting. In that case, composted MSW application nearly doubled the yield of wood without measurable adverse effects (Jokela et al., 1990). The main objectives of the silvicultural municipal solid waste (MSW) compost utilization study was to investigate the effects of composting on water-holding capacity, soil chemistry, soil/ground water quality, and tree survival and growth (Riekerk, 1995) and to demonstrate conservation of water by increasing the soil retention capacity with amendments of organic waste products.

The sites were in the Austin Cary Memorial Forest near the University of Florida in a cleared area of sandy soil with a 3 ft deep water table, and in a six-year old slash pine (Pinus elliottii) plantation forest on poorly-drained soil. The site design was chosen to evaluate the effects of leaching depths on groundwater contamination, and of weed competition on tree survival. Five-row plots within each site received on average a low (59), medium (96), and high (127) dry ton/acre of compost during the fall of 1992. Half-length 50 ft plots received 100 lb mixed fertilizer +100 lb urea + 200 lb lime (nutrient-only) or 68 dry ton/acre wood chips (carbon-only) to separate their combined effects in compost. The nutrient application with wood chips averaged about 50% of the low compost rate, and that with fertilizer was about 75%. The carbon-to-nitrogen ratio of the compost on the seedling site was 30, on the forest site 34, and of wood chips 58, while the moisture contents were 33%, 26%, and 45%, respectively. The area had 46% nitrogen, the lime 28% calcium, and the mixed fertilizer 10% each of nitrogen, phosphorus and potassium. The compost on the cleared site was disked into the soil and then planted with slash pine seedlings, but that on the forested site was only top-dressed between tree rows to avoid root damage (Figure 4-1).

Compost, soil, soil/ground water sampling and analysis lasted only for a year, but periodic tree measurements were continued over 5-1/2 years.

Water-Holding Capacity

The data from the seedling site indeed showed reduced soil bulk density, which increased field soil water content of all treatments. The high-rate compost application significantly increased saturated water-holding capacity in the seedling site. Similar results were reported for MSW compost applications up to 20 ton/acre in a young slash pine plantation (Bengston and Cornette, 1973).

Soil Surface Chemistry

The compost treatments increased the pH, mineral and organic matter levels, so could be expected from the relatively high application rates. Similar results have been reported by others (Fiskell and Pritchett, '79; Fiskell et al., 1979). Post-treatment organic matter analyses showed a 1.5-2.0 fold increase in organic matter for the high compost treatments with up to 3% organic matter in the topdressed forest soil.

The wood chips with the high soluble phosphorus content increase the phosphorus in the surface soil as much as it was expected. The high levels of phosphorus in percolating soil water suggest significant leaching, but the lack of a treatment response of the phosphorus level in ground water (at both sites) may have been caused by mineral and biological fixation in the sodic horizon (Fiskell and Pritchett, 1979).

Soil and Ground Water Quality

All treatments increased phosphorus levels in soil water of the seedling site, including a significant rise in phosphorus by the high-rate compost. In contrast, the addition of similar rates of compost to agricultural soils under laboratory conditions reduced water-extractable phosphorus levels by fixation (Craun, 1994).

Because of an unexpectedly high phosphorus level in soil water from the control plot of the forest site, significantly increased phosphorus levels could not be demonstrated for the treatments. However, the phosphorus level in soil water from the control of an earlier study on the site was about 0.24 ppm (Burger, 1979), suggesting significant increases by the treatments. The highly variable nutrient levels of soil water were increased mostly by an initial flushing effect, with the exception of nitrate-nitrogen in the high-rate compost and wood chip plots of the seedling site. A comparison of the average nitrate-nitrogen levels in water-extracts with those in soil water showed much lower ratios under compost than wood chips, suggesting nitrification of the large amount of water-soluble ammonium-nitrogen in the compost. Denitrification apparently reduced nitrate-nitrogen levels under the wet, organic-rich and neutral levels of the high-rate compost, but significant nitrogen immobilization may have been the dominant process under the wood chips with a very high carbon/nitrogen ratio of 58 (Grasset, 1994). The relatively low nitrate nitrogen level in soil water under wood chips of the forest site also suggested nitrogen immobilization, but nitrification is low in the acid soil of this site (Burger, 1979). The high pH and conductivity levels under the compost layers were generated by the significantly increased amounts of potassium and calcium in soil water, which in turn were exceeded by those of water-soluble laboratory compost extracts. The soil/ground water ratio for copper (Cu) was similar to that in a loamy soil column leaching study where the process of Cu mobility was associated with the soluble Cu supply from compost rather than being complicated by dissolved organic matter that was trapped by the subsil (Scagel et al., 1992).

The chemistry of soil water may be important for tree nutrition; however, that of ground water is of environmental concern. While soil water under all the compost treatments had higher levels of nutrient elements than the control, only the high-rate compost application generated ground water quality levels that exceeded accepted standards for a significant time interval. The main contaminant was nitrate-nitrogen, as was expected from its ionic mobility and its documentation by previous studies (Riekerk, 1986).

Tree Survival and Growth

The addition of nutrients-rich MSW compost obviously has a fertilizer effect on plant growth.
Reclamation of Phosphate Mine Lands with Compost

The phosphate mining industry annually reclaims an average of 4,000 to 5,000 acres of mine lands in Florida, making it a viable market for compost products.

The phosphate industry in Florida produces more than 71 percent of the United States' supply of phosphate. The industry is concentrated in five southwest Florida counties that include Hillsborough, Polk, Hardee, Manatee and DeSoto, where over 90 percent of Florida's phosphate is mined. In 1996, the mining industry began reclamation at a 100 percent equivalency that requires one acre to be reclaimed for every acre mined. The phosphate mining industry on average reclaims between 4,000 and 5,000 acres a year of mine lands in Florida.

Statutory and Economic Considerations

The cost to reclaim phosphate land is between $3,000 and $8,000 per acre. Earth-moving contributes the largest single expense. Mining reclamation costs for "old-lands" — those mined before July 1, 1975 — are subsidized by the State Comptroller from the Minerals Trust Fund, which is funded by a phosphate severance tax. After that date, state statutes required mandatory reclamation of mine lands by the phosphate industry itself.

The Comptroller reimburses the industry for reclamation of the old lands at a rate of $4,000 an acre for mined-out areas and $2,500 an acre for clay settling areas and other land forms. Of the 87,000 acres of old lands mined before 1975, almost half remain to be reclaimed.

Traditional Use of Organic Material by the Mining Industry

In Florida, the level of organic matter required by the Department of Transportation for establishment of vegetation is 1 percent. Soil found on mined phosphate lands usually has less than one half of one percent organic matter. The mining industry manages its soil to recover its organic content. Topsoil found in overburden is set aside for future use. Peat is seldom available. Muck is the primary material used, but its availability varies. Muck is found in wetland areas with depths ranging from a few centimeters to several meters. As part of a permit to mine wetlands, mining companies typically are required to remove and stockpile muck prior to mining and to use it later to reclaim wetlands.

At the present time, the primary reclamation activity where organic material may be required is in the re-creation of wetlands. The main reasons to save muck found on phosphate lands are its ability to provide a low cost source of wetland seeds for plant establishment and its ability to retain moisture during the dry season.

Some of the problems experienced by the industry with the mining of muck are: 1) it is not uniform in particle size, 2) it may contain nuisance plant seeds, 3) while stockpiled, its moisture level should be maintained to preserve seed and to avoid wind disbursement, and 4) muck may be found with a relatively low organic content level (around 20 percent).

Wetland creation involves the additional expense of soil recontouring of elevation to create hydrological conditions needed to form wetlands. Another associated cost to the mine company is the processing of muck that includes excavation, transfer, stockpiling and application. Blending of recycled urban plant debris with muck in order to obtain biological diversity of seed is one option for future field trials. To use recycled urban plant debris organic material in wetlands mitigation projects, it should have the following parameters: 1) be free of weed seed, 2) have a preferred pH range between 5.0 to 6.3) contain a particle size that will not float,
CHAPTER 15: RECLAMATION OF PHOSPHATE MINE LAND WITH COMPOST

4) have a level of maturity that releases nitrogen, 5) have an organic carbon range between 35 and 65 percent.

Mining Industry's Past and Present Use of Recycled Organic Material

The industry has had limited exposure to the use of urban plant debris organic material. Historically, there have been a few small scale field experiments where urban plant debris organic material was used in demonstration projects. It has been used in turf establishment on quartz sand slopes and on phospoughusm stacks.

The industry now requires that organic material be particle size-reduced, managed for weed seed and delivered by motor carrier to the reclamation site. Mining activity in Florida is located on the northern edge of the southern climate zone, which is subject to invasive, nuisance plants. For this reason, a weed seed-free material is required. Another concern by the industry is the availability of a sufficient quantity of acceptable material to meet its reclamation needs.

The Industry's Conversion to the Use of Recycled Organic Material

The most important indicator of successful reclamation is plant performance. State regulations allow one year for revegetation and one year for vegetative establishment. Soil that has been mined needs improvement to support vegetation. Addition of organic material results in increased soil fertility and the ability of vegetation to become established and self-sustaining. The use of recycled urban plant debris organic material by the phosphate industry will increase following successful demonstration projects. The industry is now exploring the development of a low cost means of land application of organic material that does not exceed its present reclamation costs per acre.

Future Uses and Benefits of Recycled Yard Waste Organic Material

The lands with the greatest potential for use of urban plant debris organic material as a soil amendment are the more sterile upland areas that receive sand tailings and the clay settling areas, where the organic content is less than one half of one percent. The successful establishment of turf in upland areas acts as a buffer to filter storm water runoff that reduces water turbidity in wetlands. Organic material also can be substituted for the application of clay that is placed in sand, where it is used to improve the cation-exchange capacity and moisture retention.

The establishment of vegetation aided by the use of organic material will improve the properties of soil structure and reduce soil erosion. The addition of organic material aids the soil's physical and chemical properties by improving cation-exchange capacity, increasing water-holding capacity, reducing the acidity in soils, and providing plant nutrients. Soil biological properties are improved by reintroduction of a microbial population in the soil.

Sheet composting. State regulations regarding the duration of time allowed for completion of reclamation is determined by the size of the land and the character of the soil. On a 400-acre tract of land, the state normally allows a total of six years, including four years for earth-moving, one year for revegetation and one year for plant establishment. A longer reclamation period is allowed for upland soils that contain sand tailings and clay settling.

Sheet composting offers a large-scale processing potential but requires, as a precondition, the availability of a large tract of land and ample time. The sheet composting process involves the formation of windrows with specially designed delivery trailers containing live bottoms. The windrows are strategically positioned for the future even distribution of material washed spread to a depth of one or two feet over large land areas. At two feet of depth, the sheet composting process accelerates decomposition by creating a lower temperature than found in windrows. This provides a broader range of microbial activity while improving the availability of oxygen and retaining water that accumulates on the bottom six inches. At a future date, the remainder of the decomposed material is cut into the soil prior to plant revegetation.

The significance of the scale of operation is illustrated by the fact that, at two feet of depth, an acre will hold 1,000 tons and a 100-acre tract will hold 100,000 tons.

Sand dam. The phosphate industry has reduced its dependence on deep well water and now relies heavily on recycling the water used to transport the slurry mix of mined ore. It also uses water as a medium to separate non-phosphate material. Quartz sand is removed from the matrix of ore material and is used to construct dams found in an elaborate network of retention lakes and canals used to remove clay and reuse the water. Quartz sand is low in nutrients and organic matter and has poor water retention qualities. To comply with the requirements of turf establishment on dams constructed of sand, the industry applies a mixture of balsam and bermuda seed to the dam face. The industry reports that, within three years, sympathetic weed growth inundates the seeded areas. Contributing to this condition is the four-to-one slope of the dam and the mid-range size of the quartz sand particle that allows water to percolate, creating dry conditions for turf establishment.

The industry is interested in experimenting in a field trial over a two-acre area of a sand dam face. Urban plant debris organic material will be blended with the sand at 0.30 and 50 percent ratios and applied to one foot depth. The year-long demonstration project will attempt to show that, as the material decomposes, it will provide moisture and nutrient retention needed to assure extended turf establishment, help-
Glossary

Biosolids: The solid material removed from wastewater after domestic sewage has been processed at wastewater treatment plants. Also known as "residuals" or "sewage sludge" (adapted from Biosolids Management in Florida, 1997).

Compost: "Solid waste that has undergone biological decomposition of organic matter, has been disinfected using composting or similar technologies, and has been stabilized to a degree which is potentially beneficial to plant growth and which is used or sold for use as a soil amendment, artificial top soil, growing medium amendment or other similar use" (Rule 62-701.200(21), Fla. Administrative Code).

Contamination: Unwanted material. Physical contaminants can include sharps, metal fragments, glass, plastic, and stones; chemical contaminants can include trace heavy metals and toxic organic compounds; biological contaminants can include pathogens. In excessive amounts, a contaminant can become a pollutant (adapted from Composting Council, 1994).

Curing: The last stage of composting that occurs after most of the readily metabolized material has been decomposed or stabilized. It provides additional biological stabilization (Composting Council, 1994).

Feedstock: Organic materials that can be composted. Commonly-used feedstocks include grass clippings and other urban plant debris, biosolids and municipal solid waste.

Heavy Metals: A group of metallic elements with concentrations that are regulated because of the potential for toxicity to humans, animals, or plants. Trace elements include copper, nickel, cadmium, lead, mercury, and zinc if present in excessive amounts (Composting Council, 1994).

Humus: A complex amorphous aggregate, formed during the microbial decomposition or alteration of plant or animal residues and products synthesized by soil organisms; principal constituents are derived from lignins, proteins, and cellulose combined with inorganic soil constituents; dark or black carbon-rich relatively stable residue resulting from the decomposition of organic matter (Composting Council, 1994).

Macronutrients: Nutrients used by plants in high quantities.

Mature Compost: Material that has gone through the window or in-vessel process for "sanitation" and has been sufficiently cured for stability so as not to introduce phytotoxic acids. Mature compost will not deplete soil nitrogen to support additional biological decomposition but will be beneficial to soil and plants grown in the amended soil (adapted from Composting Council, 1994).

Micronutrients: Nutrients required by plants in small quantities but toxic at high levels, including boron, chlorine, copper, iron, manganese, molybdenum, and zinc.

Mulch: A soil surface cover used to retain moisture by retarding evaporation, discourage weed growth, stabilize temperatures by insulating the soil, and stabilize the soil against erosion from rainfall (adapted from Composting Council, 1994).

Nitrogen Immobilization (N-robs): A condition in which microorganisms in immature compost consume the available plant nitrogen in the soil to decompose the compost. Allowing the compost to stabilize for a few months before planting or applying nitrogen as a mineral fertilizer usually corrects the problem.

Organic Matter: Any carbonaceous material (exclusive of carbonates) of animal or vegetable origin, large or small, dead or alive, consisting of hydrocarbons and their derivatives.

Pathogens: Organisms or microorganisms, including bacteria, mold, fungus, virus, and protozoa capable of producing an infection or disease in a susceptible host. Measures to control pathogens include industrial hygiene, effective design and operation for biodegradation of pathogen nutrients and adequate and uniform aeration and temperature/time to assure pathogen destruction (adapted from Composting Council, 1994).

Phytotoxins: Toxins that may endanger plant viability or functionality. (Composting Council, 1994).

Screening: A production step to mechanically classify materials by size through the use of screening equipment.

Soil Conditioner: (Soil Amendment) A soil supplement that physically stabilizes the soil, improves resistance to erosion, increases permeability to air and...
windrow: An elongated formation of urban plant debris where the dimension of construction, the particle size, and the manner of rotation provides a state to control temperatures. Windrows have a large exposed surface area which encourages passive aeration and drying.

water, improves texture and resistance to crusts, ease cultivation, or otherwise improves soil physical quality (Composting Council, 1994).

stability: A level of biological activity in a moist, warm, and aerated biomass sample. Unstable biomass consumes nitrogen and oxygen to support biological activity and generates heat, carbon dioxide, and water vapor. Unstable, active compost demands nitrogen if applied to the soil and can cause nitrogen deficiency in the soil mix and be detrimental to plant growth, even causing death of plants in some cases (Composting Council, 1994).

Urban plant debris: Grass clippings and other yard trimmings.

Water Table: The upper surface of ground water (Composting Council, 1994).

REFERENCES


Development of suggested compost post parameters and composting guidelines. The Composting Council, Alexandria, VA.


