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IFAS EXTENSION

Large Scale Utilization and Composting of Yard Waste[1]

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INTRODUCTION

Beginning January 1, 1992 all yard waste will be banned from lined landfills in Florida. Yard trash is defined by the 1988 Florida Solid Waste Management Act as vegetative matter resulting from landscape maintenance and land clearing operations; it includes tree and shrub trimmings, grass, palm fronds, leaves, trees and stumps. The purpose of this ban is to aid in the conservation of landfill space and encourage resource recovery in the form of composting and mulch production. Many other states currently have or soon will have similar bans on yard waste in landfills. However, some states define yard waste to be only leaves or leaves and grass. In Florida, operations that compost only yard waste or manure are covered by the provisions in Rule 17-709.515, Florida Administrative Code (F.A.C.). This circular describes options for yard waste use at this time, which include compost, mulch, direct land application, and boiler fuel production. The production of boiler fuel does not contribute to recycling credits. For an overview of the solid waste management act see Earle et al., 1991.

SITE LOCATION

In order to operate a solid waste facility to produce compost, a permit must be obtained from the Florida Department of Environmental Regulation. For exact permitting requirements see Rule 17-709.515, F.A.C.

Several factors need to be taken into account in site selection. Yard waste processing sites should be on well drained sandy soils. High water table sites may be flooded during the rainy season. Under these wet conditions, partially decomposed organic matter mixed with sand creates boggy conditions. Heavy equipment cannot operate under boggy conditions. An all-weather access road to the site, with an effective barrier to prevent unauthorized dumping and entry, is necessary. The site needs to be graded to minimize water ponding and a storm water management system needs to be designed for the site to prevent runoff from entering the receiving, processing, curing and storage areas. Runoff also needs to be prevented from leaving the site. Runoff can be directed to a holding pond where it can be used as a source of irrigation water for the compost during dry periods. Tree or other vegetative buffers should be included in the site plan because they aid in

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preventing the site from being a noise annoyance and they contribute to visual aesthetics and public acceptance of the site. The site should also have access to fire protection, and there should be space for future expansion. Another consideration may be to locate the operation close to available manure or sewage sources, since these materials co-compost well with yard waste. If yard waste is co-composted with sewage sludge, the site must be permitted and managed according to the sewage sludge regulations.

The site should contain a truck scale and be planned for traffic control, unloading and receiving, processing, storage and sale of the finished products. If several different products are produced at a site, the facility could be divided into areas that correspond to the processing for each product. For example, a site that produces compost, landscape chips and boiler fuel could be divided into two or three processing areas. Yard waste for composting could be received and ground in one area and then placed in another area dedicated to the composting process. After several months, depending on the feedstock and composting system used, the composting material could be moved to a curing and storage area. The woody material being processed as boiler fuel could be processed in a separate area for immediate shipping. Wood for landscape chips could probably be processed in this same area as needed. The important point is to design the site to facilitate the efficient flow of material, that is the receiving, processing, storage and sale of the materials.

COLLECTION

Yard waste can be collected from the home at curbside or from a drop off site, or it can be brought to the site by homeowners and landscapers. When yard trash is collected from the home, it may be loose or in some type of container. If the material is loose, two basic types of collection equipment are used: vacuums and mechanical scoops. The yard waste is then be placed in a truck or trash compactor.

Two types of vacuum collection equipment exist: collectors and loaders. Vacuum equipment works for leaf collection but probably will not work for brushy material that is typical of yard waste in Florida. Collectors are self contained units that have both the vacuum and the collection unit. Most collectors do not have compaction capabilities. Vacuum loaders consist only of the vacuum equipment. An accompanying vehicle must be available to receive the material from the vacuum loader.

The front-end loader with a standard bucket is a common mechanical scoop. These are not highly efficient at loading loose yard waste. Pincher-type buckets which fit on a front-end loader are also available. Another type of mechanical loader has paddles to scoop material onto a conveyor.

The type of homeowner collection containers available are bags or bins. Several different types of bags are available: standard plastic, degradable plastic and paper. Standard plastic bags do not degrade during the composting process. They must be removed from the yard waste before the composting process, preferably as the material is being placed in the trucks, or after the composting process is complete. Removal of plastic bags before the composting process helps keep the site clean and the compost product is more attractive. To remove plastic bags after composting, the compost must be screened. Biodegradable or photodegradable plastic bags do not disappear, they simply break into smaller and smaller pieces. Although these bags may degrade, the time required for them to degrade is often longer than the time of composting (Cole and Leonas, 1991). Paper bags degrade during the composting process and do not need to be removed. Reusable bins are an option to the bag removal problem. Their sizes vary; 30- to 90-gal containers are common for individual families. Containers as large as 400 gal are available for neighborhood use.

PROCESSING EQUIPMENT

Once yard waste has been received at the site it needs to be processed into various products. This section covers types of equipment related to processing of yard waste for composting and mulch.

Grinding Equipment

Grinding yard waste and other wastes accelerates the decomposition process by exposing more surface area of the material to the activity of microorganisms.

It aids in mixing different wastes, such as wastes which are high in nitrogen with those which are low in nitrogen. Also, in the case of aerobic composting, more surface area is exposed to oxygen. However, if the material is ground too fine, it can compact and oxygen is not able to penetrate the mass. This delays the rate of aerobic decomposition and can result in anaerobic conditions.

There are several types of grinders available for grinding yard trash. They fall into several categories. These include hammermills, slow speed shredders, and chipper disks. Tons of material ground per hour varies, depending on the size and design of the equipment, the nature of the material being ground, and the desired particle size. An important feature for grinding yard waste is for the grinder to have a wide throat which will accept brushy material and logs. Some systems reportedly process up to 150 tons per hour, but amounts of 20 to 30 tons per hour are more common (Glenn, 1990). Operating costs for grinders, including depreciation, may run to as much as several hundred dollars per hour.

Hammermills have 18 or more swinging or fixed hammers that grind the material. These hammers may weigh from a few pounds to over 50 pounds. Hammers need to be resurfaced or turned frequently to maintain a hard, efficient grinding surface. In Florida, the unavoidable sand in incoming yard waste dulls the hammers' grinding surface. These grinders may also have screens or bars which determine the particle size of the finished material. The tub grinder, which has a rotating cylindrical hopper, is a hammermill system commonly used for yard trash. These may have an integral power unit or may use a PTO shaft to transfer power from an auxiliary power unit or a tractor. Prices for self-powered models range from $80,000 to $180,000; for PTO powered models, from $20,000 to $40,000 (Glenn, 1990).

Slow-speed shredders and chipper disks do not use swinging hammers. Slow-speed shredders may use a system of slowly rotating augers to shred the material. Augers need to be resurfaced to maintain an effective grinding surface, but resurfacing is less frequent than with swinging hammers. Chipper disks use a high speed, rotating, "toothed" disk. Both are generally self powered. Prices may range from $25,000 to $400,000 (Glenn, 1990).

Each type of grinding equipment has advantages and disadvantages. Slow-speed shredders, for example, are usually not damaged by large pieces of metal, which may contaminate yard waste, but tub grinders may suffer extensive damage. On the other hand, tub grinders generally produce a smaller and more uniform particle size. If boiler fuel is being produced, uniformity of particle size is not as an important a consideration and chippers may be the more appropriate equipment.

Mixing Equipment

For co-composting yard waste with nutrient amendments, such as manures or sewage sludge, mixing equipment may be useful. Mixing yard waste and nutrient amendments before placing them in a composting system ensures good contact between materials high and low in nitrogen, thus permitting more uniform composting. The equipment may use an auger system to mix the material. Mixing equipment is built in two styles: continuous feed units or batch type units. Continuous feed machines may process from 10 to 300 tons per hour, while batch systems have capacities of 4 to 20 cubic yards per batch. These machines range in price from $6,000 to $100,000. If a windrow turner or other compost turning system is used at the site, separate mixing equipment may not be needed.

Compost Turners

These machines are used to aerate and mix the composting material, thereby accelerating the composting process. Several types of machines have been designed specifically for turning compost. These fall into two broad categories: machines which move through the freestanding windrow and machines which move through compost contained in a bin. In addition to these machines, front-end loaders are used for turning compost because they are usually readily available at composting sites. Front-end loaders do not mix the compost as uniformly nor accelerate the composting process as much as compost turners do.

The compost turners which move through free-standing windrows are either self-propelled or are powered by a PTO. The PTO-driven models are pushed or pulled by a tractor or other prime mover. These machines use several designs to aerate and mix the material. One design has a moving, elevating face with tines to lift, aerate and mix the material. A second type of design utilizes a rotating drum, with tines, that moves through the material, and a third type of design uses a paddle system to move the material. The height and width of the windrows must not exceed the capacity of the machine design. Maximum height and width appear to be about 9 feet by 20 feet respectively. Self contained units cost from $100,000 to $220,000, and PTO-driven units cost from $50,000 to $70,000 (Glenn, 1990).

Compost turners which move down an enclosed bin are generally of two designs: a rotating shaft with paddles or a rotating drum with tines. These units have integral power units and usually are built on a concrete slab or some other hard surface. The turners travel down rails on the side walls as they aerate and mix the compost. They are designed to move the compost down the bin and expel finished compost each day. The total residence time of the material in the bin may be 21 days or more, depending on the material and the design and operation of the system. These systems may be enclosed in a building or covered by a pole barn or quonset style structure to protect them from rain. The systems may be relatively inexpensive (under $100,000) or extremely expensive, depending on the design and capacity.

Screening Equipment

Screens may be used to remove soil, sand and fines in yard waste prior to grinding or they may be used in the finishing step to produce a uniform, high quality compost product. Decisions on the size of the screen opening to be used are usually based on the intended market for the material. Screens for processing the finished compost are used to remove debris and oversized material. Two types of screens are commonly used in yard waste composting operations: rotating, trommel screens and vibrating screens. Volumes processed through these screens may range from 15 to 400 cubic yards per hour, and the cost ranges from $15,000 to $350,000 (Glenn, 1990).

MULCH PRODUCTION

The difference between mulch and compost is that mulch is placed on the soil surface and is used as a landscape accent, to reduce weed growth and to reduce soil water evaporation. Compost is incorporated into the soil and is generally used as a soil amendment or in potting mixes to enhance soil organic matter, to increase soil water holding capacity, to increase soil cation exchange capacity and, in some cases, to add nutrients to the soil and control soil borne diseases.

In a yard waste operation two types of material are readily available for mulch production. These are heterogeneous, ground yard waste and landscape chips which are made from hard and soft woods. Landscape chips are produced from logs that have a diameter of 6 to 8 inches or more. These are chipped to the desired particle size and may be sold immediately. To produce mulch from ground yard trash, the material is ground to the desired particle size and placed in windrows or other composting system to undergo a short period of composting. The purpose of this composting period is to permit the mulch to go through a heating cycle and destroy any weed seeds and pathogens that might be present. The mulch should reach and maintain a temperature of 55°C for three days. After this time the mulch must be turned so that the exterior of the pile is exposed to the high internal temperatures. The material should be allowed to reheat and remain at 55°C for three days. If a problem with weed seeds or pathogens is suspected, this process should be repeated several times so that all of the mulch is exposed to these high temperatures. If the ground yard trash is dry at the time it is placed in the composting system, water should be added to bring the moisture content to between 45% and 60%. Without adequate moisture the material will not heat and begin the composting process. After the mulch has passed through exposure to temperatures of 55°C and above several times, it may be sold as is or it may be screened and sold. The fine material which passes through the screen can be added to windrows which are being managed for compost production or it can be sold directly as a soil amendment.

COMPOST PRODUCTION

Composting is a controlled process of microbial degradation of organic matter. Generally, and for the purpose of this discussion, it is considered to take place under aerobic conditions. During the process of composting, the decomposing material goes through several stages. When the material is first placed in windrows, it is usually at ambient temperature. As the microorganisms begin to decompose the material, the temperature begins to rise. The temperature of the material in the windrow is first in the mesophilic range (10°C to 45°C) and then rises to the thermophilic range (45°C to 70°C). Eventually, as the material becomes extensively degraded, the temperature drops back to the mesophilic range and the material is ready for use. The length of time required for this to occur depends on the material being composted and the system being used, and it may range from a few months to greater than one year. The following important aspects of composting are discussed in this section: composting systems, temperature, particle size, moisture content, carbon to nitrogen ratio, nutrient amendments, time requirements, and curing.

Composting Systems

There are four categories of composting systems: turned windrows, static piles, forced-aeration static piles, and in-vessel composting. The type of system selected depends on the land area available, the type and amount of organic material to be composted, the manpower available, the financial resources available, the desired end product and the time frame in which the material must be ready for use.

For turned windrow composting, the material to be composted is arranged in long rows (windrows) that are aerated by convective air movement, diffusion, and periodic mechanical turning that exposes the material to oxygen. The raw materials are mixed and aerated with front-end loaders or windrow turners. They are turned frequently during the initial period of high oxygen demand and heat generation and may be turned less frequently as the composting process proceeds. They may need to be turned several times per week, depending on the material being composted.

Static piles are also formed in the shape of windrows but may be higher and wider since they do not need to conform to the size of a windrow turner. The term static piles refers to the fact that these piles are not turned or are turned infrequently (several times per year), generally with a front end loader. This system tends to be less expensive in terms of manpower and equipment than windrows but requires more land area because the material decomposes more slowly and stays on the site longer.

Forced-aeration, static-pile composting is useful for co-composting yard waste with sludge or manures. A forced aeration system is placed under the piles to maintain a minimum oxygen level throughout the composting mass. This aeration system usually consists of a series of perforated pipes or floors running underneath the pile connected to a pump that draws (negative pressure) or blows (positive pressure) air through the pile.

In-vessel, bin or closed-reactor composting takes place in partially or wholly enclosed containers in which environmental conditions may be controlled. The principles of operation are essentially the same as for windrow and static pile systems in that the material is piled (in a container) and aerated by turning or forced air. In-vessel systems are more space efficient than the other options and have greater process controls. They are also much more expensive. The advantages and disadvantages of the different types of systems are listed in Tables 1 and 2.

*******TABLE 1

*******TABLE 2

COMPOSTING PROCESS PARAMETERS

Several parameters need to be considered for efficient composting. These are temperature, particle size, moisture content, carbon to nitrogen ratio, and nutrient amendments.

During the composting process, the temperature of the composting material passes through mesophilic (10°C - 45°C) and thermophilic (45°C - 70°C) temperature ranges. The temperatures generated are due to the metabolic activity of the microorganisms involved in the composting process. There are two important considerations involving temperature. First, the temperature of the composting material should reach 55°C for at least 3 days to destroy any plant, human or animal pathogens present. This temperature requirement should be reached during the several successive turnings of the material. Secondly, the temperature should not be allowed to exceed 70°C, because at temperatures above this most microorganisms involved in composting die or enter a resting phase which slows decomposition (Golueke, 1991).

Reducing particle size exposes more surface area to microbial attack and enhances decomposition. However, grinding the material too finely can cause compaction and restricted air flow which reduce the rate of composting. Also, the finer the material is ground, the more energy is consumed in the grinding process.

Yard waste is often quite dry unless it contains large amounts of grass. The moisture content may be about 30% for ground yard trash. For composting, the moisture content should be between 45-60%. Moisture can be added with irrigation guns, fire hoses, or watering attachments to the in-vessel or windrow turner or grinder. If sludge or manure is co-composted with yard waste, it can provide moisture.

Microbial activity is affected by the carbon (C) to nitrogen (N) ratio. A C/N of about 50/1 or less is preferable for composting. A C/N of 30/1 or lower is considered optimum. At ratios much above this, nitrogen becomes limiting to microorganisms and material high in carbon decomposes slowly. Yard trash that contains brushy material in addition to grass and leaves tends to have a high C/N ratio, perhaps in the range of 125 to 1. To enhance composting in material like yard waste, nutrient amendments can be co-composted with the yard waste. An average nutrient analysis of yard waste from Alachua County, Florida can be seen in Table 3.

******TABLE 3

A variety of materials can be used as nutrient amendments. All animal manures are useful as nutrient sources, although they provide differing amounts of nutrients and moisture. Sewage sludge can be a useful amendment, providing nutrients and moisture, but the composting site must be permitted for sludge use. Food processing wastes can also be used as an amendment. Seafood waste is a good amendment, although this waste may be seasonal. A steady supply of the chosen amendment is preferred. Inorganic nutrient sources such as fertilizers can also be used, but these generally must be purchased.

The use of nutrient amendments enhances the rate of composting of yard waste, but their use requires extra care. They should be mixed with the yard waste as soon as possible and turned on a regular basis (probably several times per week). If they are not, an odor and fly problem may result, except in the case of inorganic fertilizers. By co-composting a nutrient amendment with yard waste, the compost reaches a C/N ratio suitable for plant growth sooner than yard waste composted alone (Table 4). The use of nutrient amendments also affects the pH of the material, both during and after composting (Table 4).

The length of time required for composting depends on the composting system used, the initial feed stock, the initial particle size, nutrient balance and moisture content. Composting of yard waste may take anywhere from about 1-3 months in a turned windrow or in-vessel system to greater than one year in a static pile. After the material has been removed from the turned windrow or in-vessel system it is placed in a curing pile. The material continues to compost in the curing pile, but is not actively turned. The curing pile allows the material to decompose further and serves as a storage site. Compost may be sold directly from curing piles.

*******TABLE 4

OTHER USES OF YARDWASTE

Disease Suppression

Many composts, if they are prepared and handled properly, have the ability to suppress and control soilborne plant diseases. Disease control, in this case, does not refer to the process of pathogen destruction that occurs during the composting process itself. Rather, it refers to the ability of mature compost to control plant diseases in soil or potting media when the compost is mixed with media or soil containing pathogens. The incorporation of compost has been reported to suppress diseases caused by *Phytophthora spp.*, *Pythium spp.*, *Fusarium spp.*, and *Rhizoctonia solani* (Hoitink et al., 1991). Yard waste compost produced in Florida has been shown to suppress plant death of papaya caused by Phytophthora palmivora (A.W. Barkdoll, D.J. Mitchell, and R.A. Nordstedt, unpublished).

The disease suppressive quality of compost appears to be due to the microbial population of mature compost. Several bacterial and fungal species present in finished compost have been shown to be involved in disease control (Chung and Hoitink, 1990; Hardy and Sivasithamparam, 1991). These biological control agents recolonize compost during the second mesophilic stage which occurs after the thermophilic stage.

For compost to retain its biological control properties, it must be prepared properly and handled properly once it is mature. The alteration of the microbial population of the compost can destroy its ability to control disease. In research, when compost was microwaved to alter its microbial population, disease suppression was lost and 100% of the plants died (A.W. Barkdoll, D.J. Mitchell and R.A. Nordstedt, unpublished). Excessive heat alters the compost and there are indications that storing the material in plastic bags also destroys its ability to control plant disease.

Field Application

Direct field application of yard trash has also been suggested. If the yard trash contains branches and brush in addition to grass and leaves, it will need to be ground before field application. Grass and leaves can be applied directly without grinding. In either case the material should be applied to the field and incorporated the season before the planting of a crop.

Some research with field applied grass clippings in Lancaster Co., Pennsylvania indicated that grass clippings can supply some of the nitrogen fertilizer needs for field crops (Biocycle Staff, 1991). Grass was applied with a manure spreader. Soil tests indicated that less than 30% of the nitrogen in grass clippings became available during the growing season. Recommended rates of grass application for their soil types are from 5 to 15 tons/acre, to not exceed 20 tons over a five-year period. Research needs to be done on the effects of field-applied ground yard waste containing grass, leaves and brushy material because this material has a lower nitrogen and higher carbon content than grass alone.

ADDITIONAL INFORMATION

For names and addresses of manufacturers of equipment mentioned in this article, see the yearly updated guide to equipment in Biocycle, the Journal of Waste Recycling (Biocycle Staff, 1991).

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Table 1. Advantages of composting systems.

Windrow	-Rapid drying of wet material during turning. -Drier compost resulting in easier handling of the finished product. -Capacity to handle high volumes of material. -Good product stabilization. -Relatively low capital investment: pads for piles (optional), a windrow-turning machine, and generally a front-end loader and a screen (optional).
Static Pile	-Relatively low capital costs: paved surface for piles (optional), front-end loader, and a screening device (optional).
Forced-Aeration Static Pile	-Relatively low capital costs: requires a paved surface for piles, front end loader, screening device (optional), blowers and associated piping and monitoring equipment. -A high degree of pathogen destruction due to uniform pile temperatures. -Odor control through uniform aerobic conditions in the pile (yard trash composted alone does not present odor problems unless it is mainly grass). -Good product stabilization.
In-vessel	-Space efficiency. -Better process control. -Protection from adverse climate conditions. -Good odor control. -Potential heat recovery depending on the system design.

Table 2. Disadvantages of composting systems.

Windrow	-Greater land requirement than in-vessel systems. -Equipment maintenance costs may be high. -Requires careful monitoring to assure aeration and temperature rise are adequate to assure pathogen destruction. -Work may be delayed by weather conditions.
Static Pile	-Greater land requirement than windrows or in-vessel systems. -Work may be delayed by weather conditions. -Composting occurs more slowly than in other systems.
Forced-Aeration Static Pile	-Greater land requirement than in-vessel systems. -Work may be delayed by adverse weather conditions.
In-vessel	-Potentially higher capital costs. -Reliance on specialized mechanical systems may result in delays and higher maintenance costs due to breakdowns. -Potential for incomplete stabilization due to short residence time in the biologically active system. -Less flexibility in operational mode than with windrow and static pile systems.

Table 3.
