Compost: Beneficial Uses of Compost in Florida Vegetable Crops

Composting is a biological decomposition process where microorganisms convert raw organic materials into relatively stable humus-like material. During decomposition, microorganisms assimilate complex organic substances and release inorganic nutrients. An adequate composting process kills pathogens and stabilizes compost organic carbon before the material is land-applied. In 1997, 27.2 million metric tons of solid waste was produced in Florida (about 10 lb per person per day), which was twice the national average. In Florida, 11 million t of MSW, 3 million t of YT, and 0.5 million t of animal manure could be composted annually (Smith, 1994c), but the majority of wastes are currently landfilled or burned. Since a significant (50 to 65%) reduction in waste volume occurs during biological decomposition, 8 million t of compost would be produced annually if all biodegradable material in Florida was composted. Currently, there are several operating composting facilities in Florida (Table 1).

Table 1. Composting facilities operating in Florida

Name	Compost Type	Compost System	t/year
City of Miami Yard Management Facility	Yard Trimming (YT)	Windrow	10,000
Solid Waste Authority	YT and biosolids (BS)	In-vessel	60,000
Walt Disney	BS, food waste, animal manure, YT, wood chips	Static piles	7,500
City of Sarasota	BS and wood chips	In-vessel	1,500

Table 1. Composting facilities operating in Florida			
Name	Compost Type	Compost System	t/year
Comp-Lete Food, Inc.	YT and waste water residuals	Windrow	18,000
Enviro-Comp, Inc.	YT	Static piles	40,000
City of St. Petersburg. Sanitation Dept.	YT	Windrow	2,200
Sumter County Solid Waste Facility	MSW and BS	Windrow	12,000

Composts made from the following organic waste materials are available to use in Florida vegetation crop production:

Municipal solid waste includes paper, cardboard, food waste, yard waste, rubber, leather, textiles, wood, and small amounts of glass, metals, and plastics. Most of the inert (uncompostable) materials are screened out before the compost is released for use. The largest compostable portion of Florida MSW is paper.

Yard trimmings include leaves from trees and shrubs, pine needles, grass clippings, tree bark, woody branches, roots, and shredded prunings. After January 1992, Florida YT waste could no longer be accepted in a Class I landfill, so composting YT became an attractive option.

Biosolids are the solid portion of waste from municiple sewage treatment plants. Composting biosolids creates heat that can be used for the pathogen reduction required before it can be land-applied. Biosolids are often mixed with MSW ot YT to create a co-compost, because the N added by the biosolids accelerates the raw material composting process.

Florida MSW composts are regulated under Rule 17-709, "Criteria for the production and use of compost made from MSW" (DEP, 1989), which provides general guidelines for the compost user and producer. Presently, Rule 17-709 is in a review process for modification. While environmental regulators are mainly interested in compost trace metal concentrations, growers have different interests once compost has passed regulatory health and safety standards. From a commercial grower's point of view, compost quality is judged on moisture concentration, nutrient concentration, pH, soluble salts, organic matter concentration, C:N ration, water holding capacity, bulk density, cation exchange capacity, particle size, presence of weed seeds, and odor. Most benefits of soil-applied compost have been attributed to improved physical properties due to increased organic matter concentration rather than nutrient value. Optimum chemical and physical parameters for composts that might be used in vegetable crop production are listed in Table 2.

Table 2. Physical properties of compost used in vegetable production[z]

Physical Properties	Optimal range	Effect
Moisture (%)	35 - 55	Higher moisture, increased handling and transportation costs
Organic matter (%)	50 or more	Higher organic matter lowers application rate
pH	5.0 - 8.0	In acidic soil, alkaline compost will raise pH
Water holding capacity (WHC) (%)	20 - 60	Higher WHC leads to lower irrigation frequency
Soluble salts (dS@m-1)	less than 6.0	Higher than 6.0 means potential toxicity
Bulk density (lb/cu yd fresh weight)	500 - 1000	Higher moisture content means a greater bulk density
Particle size	Passes 1 inch screen	Increase soil porosity
C:N ratio	15 - 25:1	Higher C:N ratio causes "N-immobilization"
Maturity (G.I.[y])	Over 60	GI lower than 60 indicates phytotoxicity
Compost stability	Stable	Instability can cause "N-immobilization"
Weed seeds	None	Uncomposted materials disseminate weeds

[z] FDACS, 1995.
[y] G.I = (% seed germination x root length growth in % of control) /100.

Florida is a major vegetable-producing state, with 418,000 acres under cultivation each year. Sandy soils used to grow Florida vegetables have low native fertility, so they require relatively high fertilizer inputs. Minimizing fertilizer leaching or runoff has become important due to 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. While environmental regulators are mainly interested in compost trace metal concentrations, growers have different interests once compost has passed regulatory health and safety standards. From a commercial vegetable grower's point of view, compost quality is judged based on moisture and nutrient concentration, pH, soluble salts, organic matter concentration, C:N ratio, water-holding capacity, bulk density, cation exchange capacity, particle size, presence of weed seeds, and odor.

When compost is incorporated into soil, observed benefits to crop production have been attributed to improved soil physical properties due to increased organic matter concentration rather than increased nutrient availability. Optimum chemical and physical parameters for composts that might be used in vegetable crop production are listed in Table 2. Compost is not considered fertilizer, however, significant quantities of nutrients (particularly N, P, and micronutrients) become bio-available with time as compost decomposes in the soil. Amending soil with compost provides a slow-release source of nutrients, whereas mineral fertilizer is usually water-soluble and is immediately available to plants. Compost usually contains large quantities of plant-available micronutrients.

Crop injury has been linked to use of poor-quality compost, such as that from early stages of the composting process. The type and degree of plant injury is directly related to compost maturity or stability. Maturity is the degree to which it is free of phytotoxic substances that can cause delayed seed germination, or seedling and plant death; stability is the degree to which compost consumes N and O_2 in significant quantities to support biological activity, and generates heat, carbon dioxide (CO_2), and water vapor that can cause plant stunting and yellowing of leaves. Plant stunting has often been attributed to high C:N ration of the organic material before humification, and plant injury from exposure to phytotoxic compounds such as volatile fatty acids and ammonia. Phyototoxin identification in compost extracts from fresh and 5-month-old municiple solid waste (MSW) material showed that fresh compost contained acetic, propionic, isobutyric, and isovaleric acids in the largest concentrations. Acetic acid at 300 ppm concentration inhibited growth of cress seed.

In Florida, soil application of unstable 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. When immature compost is applied and a crop is planted immediately, growth inhibition and stunting may by visible for 40 to 60 days (Figure 1). When using compost with C:N ratios higher than 25 or 30, N fertilizer should be applied, or planting delayed for 6 to 10 weeks to allow the compost to stabilize in the soil.

Research on vegetable compost utilization in Florida has established several potential applications: soil amendments, soilborne disease suppression, biological weed control, alternative to polyethylene mulch, and as a transplant media.

Compost as a soil amendment

Amending Florida soil with composted materials such as biosolids, MSW, and yard trimmings (YT) has been reported to increase crop yields of bean, blackeyed pea, okra, tomato, squah, eggplant and bean, watermelon and tomato, corn, and bell pepper. 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. In sandy (Figure 2) and calcareous soil, MSW compost application rates of 40 tons/acre resulted in crop yield increases for bean and watermelon. Contradictory crop response results were found when compost was compared to a traditional fertilizer program. However, combining compost and inorganic fertilizer has generally been more effective in producing a positive plant response than seperate 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 crops. Compost that does not meet EPA 503 standards for metals concentration in biosolids should not 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.

If all of Florida's 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. 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.

Soilborne disease suppression

The colonization of compost by beneficial microorganisms during the latter stages of composting appears to be responsible for inducing disease suppression. Instead, compost controls the pathogens by keeping the beneficial microorganisms active and growing. Therefore, pathogenic agents will either not germinate or will remain inactive.

In Florida there have been few experiments in vegetable crop production under field conditions that demonstrate the use of compost in controlling soilborne pathogens. Municipal solid waste (MSW) was incorporated into calcareous soils in Dade County at 36 and 72 tons/acre and compared to an untreated control. A two-crop rotation of bush beans and southern peas were seeded. Bean emergence and yield were improved by 25% in the compost treatment compared to the untreated control. Ashy stem blight of bean caused by *Macrophomima phasolina*was severe in areas with no compost application, but was almost completely eliminated where MSW compost had been applied (Figure 3). MSW compost reduced the damage by *Rhizoctonia* 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 that it contains. 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 YT and immature MSW compost decreased germination of several perennial and annual weeds in petri dishes. Under field conditions application of immature 4-week-old MSW compost at 3 inches (45 ton/acre) or greater thickness completely inhibited weed germination and growth for 240 days after treatment (DAT) in vegetable crop row middles (Figure 4). 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. Similar weed reduction was obtained with mature MSW compost (100 tons/acre) in row-middles of bell pepper compared with an untreated control, but herbicide provided improved weed control over mature compost.

Alternative to polyethylene mulch

Polythylene mulch regulates soil temperature and moisture, reduces weed seed germination and leaching of inorganic fertilizer, and is a barrier for soil fumigants. Removal and disposal of polythylene mulch has been a major production cost to Florida growers. Therefore, utilization of composted waste materials in combination with living mulches in a bell pepper production system was investigated. Traditional raised beds were covered with polyethylene mulch, MSW (Figure 5), wood chips, or biosolids-YT compost (100 tons/acre), and bed sides were either planted with a St. Augustine grass living mulch or not planted. Bell pepper yields were higher on compost mulch plots than on unmulched plots but lower than on polyethylene-mulched beds.

Compost as a transplant medium

The vegetable transplant industry relies on peat moss as a major ingredient in soilless media. Peat is an expensive, non-renewable resource. In Florida, alternative soilless media has been investigated to grow tomato (Figure 6), cucumber, bell pepper, and citrus seedlings. 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.

Checklist for compost utilization on vegetable crops

1. Use of immature compost can cause detrimental effects on plant growth. We recommend assaying compost for the presence of phytotoxic compounds using a cress seed germination test. In this test, a compost sample is saturated with water, and the extract is squeezed from the sample. A portion of the extract is used to moisten filter paper in a petri dish, on which cress seeds are placed and allowed to stand for 24 hours. The germination index (GI) is measured as GI = [(% cress seed germination x root length in % of the control)/100]. If GI is less than 60, allow about 90 days between the time of compost application and planting of the crop. For example, if cress germination and root length on compost was 40% and 2 inches, and the control 80% and 1 inch, respectively, therefore we obtained a 50% cress seed germination and 50% root length as % of the control. Thus, the GI = 25, indicating immature compost. An alternative measure is to continue composting the material to maturity before it is applied.

2. Most vegetable crops are sensitive to high soluble salts, especially when they are direct-seeded. We recommend measuring the soluble salts concentration of a saturation extract. If the electrical conductivity (EC) is below 6.0 dS/m, no salt toxicity should occur. If the EC is about 6.0 dS/m, the amended soil should be leached with water before planting seeds (only a few crops can tolerate this salt level).

3. High C:N compost can result in N immobilization. Have the compost analyzed for C:N ratio. If it is above 25:1 to 30:1, some N fertilizer applied to the crop may be immobilized due to N immobilization, possibly causing plant N deficiency.

4. Lack of equipment to spread compost in vegetable fields is a concern. We encourage compost facilities to play an active role in developing spreading equipment.