Recycling Urban and Agricultural Organics in Fields and Forests

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About 750 million dry metric tons of biodegradable organic wastes are produced annually in the US. The 1995, official Florida population was more than 13.8 million and the total amount of municipal solid waste produced annually grew to about 24.3 million tons (Anon., 19%). This translates into 9.6 lb/person/d or 1.7 ton /person/yr. On a per capita basis, Floridians generate twice the national average. The total organics stream includes materials produced by livestock, crop residues, biosolids, food processing, logging, and wood manufacturing, other industries, and municipal refuse. The current method for processing of organic residues leads to environmental problems and is not sustainable. However, there is a growing recognition and appreciation of the need for and the benefits resulting from effective management of biodegradable organic materials, to the point that such materials are often regarded as resources. Because of this, alternative methods of organic material recycling and processing which promote conversion to useful products are being advocated. Cost-effective integrated organic resources management to provide soil amendments and other useful products linked to a system to redirect the products to beneficial uses would lead to sustainable ecosystems and solve the environmental and economic problems facing society.

Organic materials represent a significant quantity of feedstocks for conversion to compost, stabilized residues that can improve soil physical and chemical conditions. Utilization of organic material is of utmost importance in maintaining the tilth, fertility, and productivity of agricultural soils, protecting them from water and wind erosion, and preventing nutrient losses through runoff and leaching. Organic materials can also increase soil water-holding capacity, water infiltration, aeration and permeability, aggregation and rooting depth; decrease soil crusting and bulk density; keep soil organisms balanced; and reduce soil pathogens (Shiralipour et al., 1992).

Several ongoing projects coordinated by the UF/IFAS Center for Biomass Programs are designed to demonstrate the benefits and safe use of compost applications in various uses. There are *two* comprehensive statewide projects and several others that target specific uses. The two active comprehensive projects build upon an earlier large project addressing water conservation benefits (Smith, 1994; 1995).

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A MARKET DEVELOPMENT PROGRAM FOR COMPOSTS IN FLORIDA

Demonstration of Safe Use of Compost

To remove barriers to compost acceptance, a set of projects was designed to: 1) demonstrate the biological and chemical remediation of pesticides during composting, and 2) compost maturity/stability measures important to N and toxic metal availability and accumulation in crop parts.

Demonstrate the biological and chemical remediation of pesticides during composting

Black Kow^{R} manure compost and cornposts from various facilities in Florida were used for pesticide assays. A quality assurance (QA), quality control (QC) testing protocol was established for pesticide (endnn, lindane, methoxychlor, toxaphene) and herbicide (2,4-D, silvex) detection in compost. Samples tested thus far have confirmed the hypothesis that pesticides are not present in mature/stable composts. This is either from not being present to begin with or from remediation of the chemicals through the composting operation. Air-tight composters have been designed to study the bioremediation when composts are "spiked with known quantities of a pesticide. Radio-labeled atrazine is the model herbicide being used.

Compost maturity/stability measures important to N and *toxic* metal availability and accumulation in crop parts

Several methodologies were utilized to measure the maturity/stability of the compost products. These methods include total C/N ratio, water-extractable organic C and N and also its ratio, optical density of the water-extract, and respiratory study based on CO_2 evolution. The most reliable and clear indicator for compost maturity/stability was determined to be respiratory release of CO_2.

Although the total nutrient and heavy metal quantity varied in different composts, in all cases, the levels were far lower than the limits established by Department of Environmental Protection (DEP) regulations. Waterextractable metals were low, verifying that the bioavailability of metals from these materials do not pose risks.

Demonstration of Compost Benefits

A set of projects was designed to demonstrate the benefits of compost applications to: 1) sandy soils used for vegetable crop production, 2) landscape beds to enhance establishment of woody ornamentals, and 3) turfgrass soils to determine effect on N release and on leaching of nutrients and organic compounds.

Several compost types were utilized in these projects, These included urban plant debris (yard waste) compost obtained from Enviro-Comp Facility (Jacksonville, FL), biosolids composted with UPD from Palm Beach Solid Waste Authority Facility (Palm Beach, FL), municipal solid waste (MSW) composted with biosolids from Bedminster Facility (Sevierville, TN), and MSW compost from Sumter County, FL.

Benefits of compost applications to sandy soils used for vegetable production

This project was initiated to build upon the base knowledge obtained in 1992 and 1993. Compost was applied to tomatoes *(Lycopersicon esculentum)* planted in rotation with watermelons *(Citrullus lanatus)* and tomatoes in rotation with bell peppers *(Capsicum annuum)*. The results indicated that: a) immature compost delayed tomato plant growth due to N-rob; b) when tomatoes were planted in rotation following peppers grown in compost treated soil, yield of tomatoes was 30% greater than yield without compost treatment; c) watermelons planted in rotation following tomatoes produced 30% to 50 % yield increase compared to soil with no compost treatment; and d) compost increased soil organic matter concentration, water-holding capacity, soil mineral concentrations, and pH in proportion to rate.

The objectives of the subsequent project were to determine the optimum scheduling of compost applications for improvement of soil physical properties important to transplant health, stand establishment, crop yield, and crop quality. Although the bell pepper and tomato plants grew well in both compost-amended and unamended plots, benefits were obtained in terms of increased yield and fruit quality. Extra-large tomato yield was significantly greater where Enviro-Comp compost was applied compared to unamended soil. Marketable yield in 25-lb cartons/a was 1158 for Enviro-Comp in comparison to 939 for the unamended soil. The unamended treatment produced the largest yield of medium tomatoes (410 cartons in comparison to 325, 370, and 337 cartons for Bedminster, Palm Beach County, and Enviro-Comp, respectively), had the highest percentage of fruit with "yellow shoulder" (28% in comparison to 9%, 16%, and 7% for Bedminster, Palm Beach County, and Enviro-Comp, respectively), and produced the firmest tomatoes. Tomatoes from the Bedminster compost treatment took 1 to 1.5 d longer to naturally turn from green to red at room temperature (15.1 d in comparison to 13.5, 13.3, and 14.1 d for Palm Beach County, Enviro-Comp, and unamended treatment). There were no statistically significant differences among tomatoes for plant dry weight (195 g, 175 g, 165 g, and 174 g per plant for Bedminster, Palm Beach County, Enviro-Comp, and unamended treatment, respectively) or any of the other yield or quality variables measured (percent of fruit rots, fruit scars, fruit puncture, fruit cracks, fruit zipper, and fruit shrivel).

'Fancy' bell pepper yield was greatest in the Bedminster compost treatment compared to the other treatments (397 cartons compared to 323,335, and 349 for Bedminster, Balm Beach County, and unamended treatments, respectively). There was no differences in total pepper yield between the treatments (1335, 1325, 1340, and 1254 cartons for Bedminster, Palm Beach, Envirc–Comp, and untreated, respectively). The Enviro-Comp treatment produced the firmest peppers, and the unamended treatment produced the softest. There was no difference between treatments in terms of fruit color or post-harvest variables measured. Benefits were also evident with the spring watermelon crop (in the ground at the time of the reporting).

The soil water characteristic curve was determined for unamended sandy soil that was amended with the high rate of Bedminster (80 ton/a), Palm Beach County (27 ton/a), and Enviro-Comp (80 ton/a) composts. Soils used for the measurement of water-holding capacity were sampled from plots immediately after tomato and bell pepper seedlings were transplanted, which was 2 to 4 mo. after compost incorporation. Only the Enviro-Comp treatment showed slightly higher water-holding capacity than unamended soil.

Compost applied to landscape beds to enhance establishment of woody ornamentals

In earlier experiments, woody plants were grownin pots with media mixes. In the potting media, composted materials from various facilities were evaluated in treatments ranging from 100% compost to 100% replacement of just the peat portion of the

container media. Biomass data were compiled for some woody ornamentals grown in containers with composts and compared to a control commercial mix. Biomass production in stand-alone composts was greater than in the control medium in many cases. Other compost treatments produced biomass levels similar or better than the control.

As a follow up, this project is determining if cornposts incorporated in landscape soils hastens establishment of container grown woody shrubs and the causes for the improved root growth and other biological measures associated with the compost application. Three types of composts (Bedminster, Palm Beach County, and Enviro-Comp) were applied at 1, 2, 3, and 4 in layers. Two irrigation regimes were applied: heavy irrigation (daily for the first 2 mo, every other day for the 3rd and 4th mo, and twice a wk afterwards) and light irrigation (every other day for the first 2 mo, twice a wk for the 3rd and 4th mo and once a wk afterwards). Compost treatments had no significant effect on estimated root mass for ligustrum *(Ligustrum* sp.). However, the control and the lowest levels of compost amendments had the greatest root mass for Viburnum *(Viburnum* sp). Imgation regime appears to have little effect on root growth of any species. Soil treatments, however, are having significant effects on root growth. Analysis of data suggests that canopy effects are opposite to those measured in the roots. Plants grown in highest levels of compost appear to have larger canopies and higher levels of tissue N. High N levels in the tissue my explain what appears to be lower root:shoot ratios. All compost amendments appear to have completely substituted for fertilization requirements. The optimum soil treatment to date appears to be 2 in of the Palm Beach County compost.

Effect of compost in turfgrass soils on N release and on leachig of nutrients

Earlier tests indicated that a rate of 30 to 70% compost to sandy soil in pots was optimum for growth and quality of turfgrass (St. Augustinegrass) *(Stenotaphrum secundatum).* A municipal solid waste compost was incorporated into a fine sandy soil. Compost incorporation consistently increased the quality of St. Augustinegrass. Clipping weights generally were greater from compost amended plots. During dry periods, the established turfgrass did not wilt as quickly, thus reducing the frequency of irrigation.

Although composts contained nutrients in addition to those from fertilizer, nutrients in the leachmg water were reduced. In compost treated soil, pesticides were not detected in water leached from the soil. Compost treatments up to 30% resulted in improved nutrient retention (less leachmg). This project is determining the rate of N mineralization in three compost (yard trimmings, biosolids, MSW) and identifiig laboratory indices related to the mineralization.

Field, greenhouse, and laboratory studies were conducted subsequently to evaluate N release from three compost sources. The Palm Beach Solid Waste Authority biosolid compost had the highest content of N, and the Enviro-Comp had both the lowest content of N and the highest C/N ratio. Based on available mineralization data from the first year, Palm Beach compost released the greatest amount of N and the Enviro-Comp source. the least. No volatile or semi-volatile organic were found in $CaCL_2$ extracts from compost-topsoil mixes.

Evaluation of Composted Materials to be Utilized in Florida Road and Median Plantings

Under a grant awarded by the Florida Department of Transportation, the University of Florida's Department of Environmental Horticulture and the Soil and Water Science Department are conducting both field and greenhouse studies to evaluate and recommend specifications for compost as a soil amendment in roadside plantings. The 3-yr project will examine germination, growth, and establishment of utility turf in soil amended at three different rates with three types of commonly available, commercially produced compost and will evaluate turf response to the nutritional value of manure - and biosolid-based composts applied as top dressing.

The three types of compost utilized in the study are: 1) a straight yard waste compost provided by Enviro-Comp in Jacksonville and *AmeriGro* in south Florida, 2) a yard waste with biosolids compost provided by the Palm Beach County Solid Waste Authority, and 3) a municipal solid waste with biosolids compost provided by the Bedminster facility in Sevierville, TN. Because the study seeks to establish the high-end loading tolerance for the often poor and severely disturbed soils found along newly constructed roads, compost application rates in the field were 100, 200, and 300 dry metric ton/ha. The compost is tilled into existing soil to a depth of 15 to 20 cm. The field study portion of the project is being conducted at sites in south, central and north Florida (Broward, Hernando, and Taylor counties, respectively).

Two greenhouse studies have been completed, and a third is under way in the University of Florida Envirotron in Gainesville. These tests use three soil types (< 1% organic matter, > 1% organic matter, and sand) and three rates of incorporation (15%, 30% and 60%) for

each of the composts The amended soils and the controls are seeded with an 80:20 mix of bahiagrass (*Paspu1um notaturn)/bermudagrass (Cynodon dactylon* In addition to evaluating rates of germination, establishment, and yields, the investigators are collecting and analyzingpot leachates.

Preliminary plans for a field study evaluating several types of compost astop dressing for existing stands of grasshave been developed and a site selected. Also, included in the project is a literature search, which has been conducted, as well as a telephone survey of Departments of Transportation in selected states regarding their specifcations for and utilization of compost. Telephone interviews have also been conducted with various government and private environmental and waste management agencies aswell as with academic researchers at thisand other institutions. The standards specifiedby the University of Florida team must go throughthe approval process and be finalized by the Florida Department of Transportation (DOT) before production of the educational materials for use with training DOT personnel.

Selected Projects

Below are some projects supported by the Center to position faculty to be competitive for extra-mural funding and/or solve short-term problems:

Impact of Compost on Plant Growth and Irrigation Demand (Demonstration)

Composted municipal solid wastes (MSW) from the Sumter County Solid Waste Facility were applied at the Alachua County Extension Office. The material was spread on the plot in a 4-in-thick layer (approximately 200 ton/a) and was rototilled to a depth of approximately 5 to 6 in.

Both areas with and without the compost, were planted with identical landscape plants. For the large background plants, fetterbush *(Lyonia lucida),* radish palm (fam. *Palmae*), and needle palm *(Rhupidophyllum hysterix)* were selected. For medium size filler, dwarf nandina *(Nandina* domestica) and in the front, liriope (Liriope *muscari)* 'Evergreen Giant' were planted. After planting, the lateral lines of the irrigation system were installed and the area was mulched with pine straw. The addition of composted material resulted in significant water use reduction. The soil water potential remained higher for the longer time and the irrigation system did not operate asfrequently. During the test period, the total water savings in the compost treated area were 12% compared to the untreated area

Municipal Solid Waste Compost Application to Annual Ryegrass

Municipal solid wastes (MSW) compost from Sumter County was applied and disked in at either 26, 52, or 104 dry tons/a (dt/a). For comparison, yard waste composts from three. sources were applied and disked in at either 9, 18, or 36 dt/a, and combined kitchen and yard waste compostwas applied and disked in at either 4, 8, or 16 dt/a. These plots were compared to plots treated with 0,150,300, or *600* lb. N/a as ammonium nitrate. Annual ryegrass was grown and harvested monthly. Without irrigation, a good stand of ryegrass was achieved on plots treatedwith MSW compost. The rate of application that appeared to give the best growth was 52 dt/a for the MSW compost. The kitchen and yard waste combined compostapplied at 8 dt/a resulted in the highest yields for that type of compost. All of the yard waste compost applicationsresulted in spotty germinatino and relatively reduced yield. It is expected this may be due to N immobilization or physical impedient of germination or reduced water infiltration.

Grass Forage Production Following Land Application of Urban Plant Debris.

Plots were set up in a Gilchrist County field where 200 ton/a of urban plant debris (UPD) had been incorporated into the soil without any processing 3 or 9 mo prior to planting. Nitrogen fertilizer was added at 0, 100, and 200 lb/a. Where UPD had been applied 9 mo before planting: sorghum-sudangrass *(Sorghum bicolor* x S. sudanense) showed no N deficiency, produced just as much without N fertilizer as with N fertilizer, and averaged 21 tons of fresh forage (2.5 tons of dry weight)/a. Where W D had been applied 3 mo before planting: sorghum-sudangrass growth was stunted without N fertilizer, yield was considerably less than where UPD had been incorporated for 9 mo, either 100 or 200 lb fertilizer N/a produced an average of 13 tons of fresh forage /a (1.4 tons of *dry* weightla), and yield without fertilizer Nwas 7.3 tons of fresh forage/a (0.8 ton *dry* wt/a).

Compost Application in Forests

Growth and elemental content of slash pine *(Pinus elliottii)* 16 yr after treatment with garbage composted with sewage sludge.

This study has assessed tree growth and elemental tissue concentrations in a slash pine In plantation treated 16 yr previously with four rates (0, 112, 224, and 448 metric ton/ha) of municipal solid waste (MSW) composted with sewage sludge. Tree

growth was significantly greater where MSW compost was applied Stem wood biomass increased from 55.7 to 94.7 metric ton/ha, a 1.7-foldincrease over the control for the heaviest compost application rate. Annual tree basal area increment responses were also largest and most long-lasting (up to 9 yr) for the 448 metric ton/ha rate. Significant but modest treatment-associated increases in concentrations of N, P, B, Fe, Al, and Zn in pine tissues (foliage, stem wood), and of P and Ca in Rubus spp., a dominant understory plant, were found *after* 16yr. Analysis of pine xylem tissues corresponding to the juvenile and post-crown closure growth phases revealed significantly higher concentrations of K, Ca, Mg, Cu, Al, and Zn in the later period. Results suggest that land spreading and recycling degradable organic wastes in forests can increase tree and understory growth without long-term deleterious ecosystem effects.

Compost test demonstration in slash pine forested watershed.

In 1970, an experiment using composted garbage was installed that doubled slash pine growth where composts were applied. Subsequently another pine research project was installed to demonstrate the benefits of composted MSW for tree growth and to observe the resulting physical and chemical changes. Composted MSW was applied on 15x30 m plots, at levels of approximately 100, 200, and 300 *dry* metric ton/ha, at two different flatwoods sites. At one site (seedling site), compost was applied and incorporated into a sandy bare soil and slash pine seedlings were subsequently planted. At the other site (forest site), the compost was top dressed between the rows of a 6.5-yr-old slash pine plantation. Weed competition at the seedling site was severe, and by the second yr after planting, < 5% of the seedlings had survived. Tree growth increased about 50% with the two higher application rates at the forest site. Soil water content increased at the seedling site where the compost was incorporated, but decreased at the forest site where the compost was **top** dressed.

CONCLUSIONS

The research projects presented here are addressing several important compost parameters and utilization opportunities. These projects revealed that application of compost pose no serious threats and if mature, composts are safe and can result in benefits to plant production.

ACKNOWLEDGMENTS

The projects presented here are completed or are ongoing by the following IFAS researchers: R.C. Beeson, G.H. Brinen, J.L. Cisar, S.R. Colbert, G. Fitzpatrick, R.N. Gallaher, D. Graetz, D. Haman, E.J. Jokela, G. Kidder, L. Korhnak, M. Marshall, T. Obreza, D. O'Keefe, J. Rechcigl, H. Riekerk, G.H. Snyder, A. Shiralipour, W.H. Smith, N.P. Thompson, C.S. Vavrina, M. Weaver, C.I. Wei, W.B. Wheeler.

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