Overview of Research on Compost in the USA

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In a dedicated issue of Biomass and Bioenergy (Vol. 3, Nos. 3-4, 1992), the literature on various aspects of composting and compost utilization research was compiled. Recently, several projects have been initiated nationwide to build upon that base of knowledge. A solicitation was made to all states to identify active projects on composting and compost utilization. Below is a summary of the responses I received.[1]

1. California, Dr. Aziz Shiralipour. Crops: Broccoli and lettuce, marigold and salvia flowers: Greenhouse studies determined the optimum rates of compost application for broccoli and lettuce in different soil types. Lower rates of compost applications were more desirable in the loamy sand soil, while higher rates resulted in phytotoxicity. Higher rates of compost applications in loam and clay loam soils resulted in higher yields. Plant vigor and the number of marigold flowers improved significantly when 15%, 30%, 45% or 60% of a potting mix containing peat moss, vermiculite and perlite with a 2:1:1 ratio was replaced by compost. Compost rates of 0, 15, and 30 t/a as well as nitrogen rates of 0, 30 or 60 lbs/a were applied to broccoli, lettuce and salvia in small-scale field tests. In all compost treated plots, yields were higher than in fertilizer treated plots. The organic toxicant and heavy metal contents of the broccoli heads and lettuce leaves in compost treated tissues were not significantly higher than the fertilizer treated or control tissues. Based on the results of the greenhouse and the field tests, compost field demonstrations will be conducted in September, 1994.

2. Connecticut, Dr. Abigail A. Maynard. Crops: Nursery stock--Acer, Quercus, Pinus. Plots were established with MSW compost applied at rates, 0, 25, 50 T/A (incorporated) and 100 T/A (mulch). The highest growth indices in the first year were from plots receiving 25 T/A for all species. Plots receiving T/A MSW compost had similar growth indices as the unamended control plots. Plots receiving 100 T/A MSW compost had the lowest growth indices for all species except for surviving Pinus where it was the second highest. Nitrate in groundwater remains below 10 ppm beneath all amended plots.

3. Florida, Dr. Richard Beeson. Crops: Viburnum, Ligustrum, Azalea, Pittosporum: Twenty percent (by volume) MSW compost produced plants larger than the 20% peat control for ligustrum and `Fashion' azalea and just as large as the peat control for viburnum. Use of 30% or greater compost generally resulted in plants no larger or smaller than the control. There was no evidence of water conservation through incorporation of increasing amounts of compost. Media physical properties were similar between the peat control and 10 and 20% MSW compost media throughout the first 6 months after potting. Air porosity declined with increasing percentage of compost and became detrimental for root growth above 20% compost by volume. By 8 months after potting, most physical properties were still similar between the peat control and 20% compost media except estimated plant available water was 50% greater in the 20% compost than the control medium. Nickel and cadmium levels in the plant tissue increased with increasing compost in the media but lead did not. No mineral toxicities were observed and leaching of heavy metals was just above detection levels. In the landscape, incorporation of YW compost tremendously promoted root growth, shoot growth and increased leaf areas of pittosporum and to a lesser extent for azaleas. The effect of compost appears linear up to 4 inches incorporated into 6 inches of soil. Incorporation of compost appears to substitute for more frequent irrigation in the pittosporum. In containers, YW compost comprising up to 80% of the media volume has produced pittosporum of equal quality to 20% peat controls under optimum (daily) and sub-optimum (alternate day) irrigation. Root development was similar within an irrigation regime among

[1]These reports were compiled by Wayne H. Smith, University of Florida, to inform readers of the projects. The data are preliminary and not completely analyzed. Reference may be made to the project, but no data nor interpretation should be cited without written permission of the principal investigator.

media treatments. Overall 40% YW compost appears to be superior to 20% peat for both species.

4. Florida, Drs. Herb Bryan, Bruce Schaffer and Jonathan Crane. Crops: Tomatoes and squash. Squash: Both Bedminster (Tennessee) and Reuter (Florida) sources of compost significantly improved crop canopy; early and total yields of small and marketable fruits and fruit size compared to plots with no compost. The Bedminster compost had an adverse effect on early seedling growth, presumably due to incomplete composting or a contaminant in the compost material. However, yields of squash plants grown in that materials were not significantly reduced. The unusually heavy rainfall, particularly in October and November, probably had a great influence on lack of crop response to irrigation rates. Tomato: Preliminary analyses (pooling the Texas and Tennessee sources of Eweson compost) showed no interactions among compost source, compost rate, irrigation type or irrigation rate for any of the plant growth and yield variables measured. There were no effects of irrigation rate or compost rate on any of the variables tested. For irrigation type, when compost treatments were pooled, drip irrigation resulted in higher large fruit yields than sprinkler irrigation. For compost source, addition of either Eweson or Earthlife composts delayed earliness (fewer red fruit at first harvest), increased large and marketable fruit yields and decreased cull yield compared to the control with no compost application.

5. Florida, Drs. John Cisar and George Snyder. Crops: Turfgrass/Landscape and St. Augustinegrass. Growth and quality of St. Augustinegrass was optimum when 30% compost (v/v) was incorporated in sandy soil in pots. A municipal solid waste (MSW) compost was spread 5 cm deep and rototilled to a depth of approximately 15 cm into Hallandale fine sand soil. The compost contained 60% dry matter and was 47% ash (dry weight basis). Control plots were rototilled, but received no compost. On the following day, muck-grown St. Augustinegrass sod was placed on all plots. The plots were irrigated to prevent wilting and were fertilized periodically with a 16-4-8 (N-P_2O_5-K_2O) material. Plots were periodically rated for overall quality, and the weight and mineral content of clippings were evaluated periodically. During several dry periods, irrigation was withheld and plots were visually rated for wilting. Compost incorporation consistently increased the quality of the St. Augustinegrass. Clipping weights generally were greater from compost-amended plots. During dry periods in the spring when irrigation was withheld, reduced wilting was observed in compost-amended plots, which may have contributed to improved quality ratings and clipping weights. However, it also appeared that either the compost directly supplied plant nutrients to the turfgrass, or that it improved retention of applied nutrients. The N, P, and K content of clippings, and total N, P, and K uptake, generally were greater in compost-amended plots.

6. Florida, Drs. Gary Clark, Craig Stanley and Donald Maynard. Crops: Bell peppers and tomatoes. Reuter compost applied in 1992 at 0, 30 and 60 t/a decreased pepper yield (7 and 14%) due to immaturity and N-rob as compost rates increased. Tomatoes were then planted on the same plots that received irrigation by drip and subirrigation procedures with 160 and 230 lb/A of N fertilizer. Addition of compost to the drip irrigated plots increased yield of extra large fruit and total marketable fruit. For example, at the low N treatment total fruit yield was increased from approximately 2100 boxes (25 lb.) to over 2600 boxes of fruit per acre. Only yield of extra large fruit was affected by fertilizer in the subirrigated plots. Even though there was considerable variability in soil water measures where compost was applied, soil water content was higher in proportion to compost rates. In 1993 the soils data indicate a stabilization of the compost. The plots were rebedded, fumigated and fertilized in 8/93 for the fall pepper study. Fresh market pepper yields were greater on MSWC amended plots in both subirrigated and drip-irrigated in fall 1993 studies.

7. Florida, Dr. A. E. Dudeck. Crops: Turfgrass/Sod and St. Augustinegrass. St. Augustinegrass was grown under a rain-out shelter in 3 composted solid wastes at 10, 20 or 30% by volume in the top 15 cm of sand soil and received fertigation every 3, 6 or 9 days. Composts incorporated at 30% enhanced early grass establishment with less water stress. Grass growth in 30% MSW was better than grass growth in MSW + SS and in yard trash composts at the same rate of incorporation. Frequent, short periods of mild water stress reduced top growth compared to infrequent, prolonged periods of moderate to high water stress. Irrigation frequency did not influence root distribution of Floratam St. Augustinegrass grown in a container. Visual wilt was a good estimator of leaf water potential in Floratam St. Augustinegrass.

8. Florida, Dr. George Fitzpatrick. Crops: Philodendron, Latana, Schefflera, Oleander, Jessamine, West Indian Mahogany, Live Oak. Biomass data were compiled for four species grown in containers with stand-alone composts or where compost replaced peat in a control commercial mix (4 peat, 5 pine bark, 1 sand). For lantana in stand-alone, Reuter and sludge/yard trimmings composts, plant biomass was greater than in the control medium. Other compost treatments produced biomass levels similar to the controls. In dwarf schefflera and philodendron, the Reuter compost and the sludge/yard trimmings compost, both as a stand-alone medium or blended, produced plants with greater biomass than those in control medium. With orange-jessamine, only the sludge/yard trimmings compost produced plants with greater biomass than the control medium. West Indian mahogany trees were replanted in the landscape site in preparation for follow-up of work on the effects of compost topdressing on transplant stress. Due to high rainfall, withholding irrigation did not cause transplant stress.

9. Florida, Dr. George Fitzpatrick. Crops: Ficus, Aveca Palm, Jessamine, Dwarf Oleander, Hibiscus, Philodendron, Schefflera, West Indian Mahogany. West Indian Mahogany (Swietenia mahagoni) (L.) Jacq.) liners were planted in 2 different nursery container types: (1) a standard black plastic container (SBPC) and (2) an air root pruning container (ARPC) made of aluminum with corrugated sidewalls. Plants were grown for 12 months in media mixes composed of varying proportions of a co-compost made of biosolids (dewatered sewage sludge) and yard trimmings (co-compost made by the Palm Beach Solid Waste Authority). Co-compost proportions were 30% mixed with 60% pine bark and 10% sand, 50% co-compost mixed with 50% pine bark, and a 100% co-compost used as a stand-alone medium. The control medium was 40% peat, 50% pine bark, 10% sand. At the end of production, mahoganies grown in the 30% and 50% co-compost mixes were taller in the ARPC than in SBPC, but when grown in 100% co-compost, the trees were taller in the SBPC. Trees grown in ARPC had lower root weights and higher shoot to root ratios regardless of the medium used, and trees grown in unscreened 100% co-compost had lower total dry weights than trees grown in screened (1/2" screen) 100% co-compost, regardless of the container type. A similar experiment to the one described above, with dwarf oleander, is scheduled for harvest in late June, 1994.

10. Florida, Dr. Ray N. Gallaher. Crops: I--Field Corn, II--Sweetcorn, okra, squash and cowpea. Cumulative applications of yard waste compost (YWC) have totaled 360, 300, and 240 t/a for some treatments depending upon the experiment during the past 3-years. Soil organic matter has more than doubled in some treatments. Increased silage yields from use of YWC (year 2) ranged from 2.5 t/a to 6.0 t/a, valued at $75/a to $180/a, depending upon the experiment. Much of this yield response is likely due to the increased soil organic matter, improved soil fertility conditions, reduced phytoparasitic nematodes and greatly increased soil water storage capacity. The top 24 in of soil treated with YWC for a mulch contained as much as 2.3 ac inches more water at corn planting time than the control without YWC. Cost to replace this much water through irrigation would cost between $20 and $40/a depending upon the system used. The third year of the study is still ongoing.

11. Florida, Dr. James H. Graham. Crops: Citrus. Orlando tangelo trees on Cleopatra mandarin rootstock, inoculated with Phytophthora nicotianae or noninoculated were planted at 20 x 6 foot spacing into plots amended with 100 T/a compost or into plots. At transplant, an additional 0.05 yd^3 was added to the back-fill of the planting hole in amended plots. Carbon and nitrogen content of the soil were both increased four-fold thus C/N ratio remained unchanged. At 14 months after transplant, compost increased stem caliper of Phytophthora-infested and noninfested trees alike. Phytophthora infestation in nonamended and compost-amended plots reduced root mass density irrespective of compost treatment. Additional studies of root health in nonbearing and bearing citrus orchards utilizing MSW compost in the back-fill and/or as top dressings are underway.

12. Florida, Dr. Dale R. Hensel. Crops: Potatoes. Potato yields were increased from 330 to 360 cwt/A when compost was increased from 0 to 60 t/A, respectively. When 65 lbs/A of extra N was applied to the basic rate of 210 lbs/A, no increase in potato yield was noted at the highest compost rate. At the lower compost rates, 15 to 20 cwt/A more potatoes were produced when the extra N was added. Nematode samples taken in August showed no difference between treatments. They were relatively low numbers.

13. Florida, Dr. Stephen Kostewicz. Crops: Vegetables, various. In 1991 application of 0, 25, 50 and 100 tons/acre of CYW were made to an Arredondo sand soil at the Organic Gardening Research and Education Park on the campus of the University of Florida in Gainesville. Fertilizer was added or not added to plots. Vegetables were grown continuously on the area for one year. Growth and yield data were accumulated. The area was fallow during 1992. In 1993 the original plots were subdivided and a repeat application of CYW was made to half of each plot. Pole beans were grown during the spring-summer season. Soil tests were conducted periodically throughout the 3 year period. Vegetable yield was greatest where fertilizer was added regardless of the rate of CYW applied. With high rates of CYW added, some yields were greater than where no CYW was added, particularly as time in soil increased. Immature CYW reduced yield by N tie-up.

14. Florida, Drs. Stephen Kostewicz and James Stephens. Crops: Vegetables, various. Yard wastes and other high C/N composted materials provide optimum results only when fertilizers (organic or standard type) are added with the composts. Yield response to applications of organic soil amendments/fertilizer was evaluated in cucumber, mustard greens, southern peas, and tomato. Amendments/fertilizer were broadcast, banded or mixed under plants at low and high rates over 5 seasons. Composted yard waste (CYW) showed promise as a good soil amendment for vegetables, given sufficient time in the soil (over 1 year) when used alone, or when supplemented with organic fertilizer. The "burning" effect observed for poultry compost and organic fertilizer placed in transplant holes was eliminated by mixing these materials with CYW. Organic fertilizer (Fertrell 3-2-3) gave excellent results with most crops evaluated, either alone or when mixed with CYW.

15. Florida, Dr. Thomas Obreza. Crops: Tomatoes and watermelons. In 1992 and 1993, Reuter compost was applied at 33 and 50 dry tons/acre, and Bedminster compost at 6 and 12 dry tons/acre. A standard fertilizer control with no compost and a chicken manure compost treatment were included. Plots were planted with tomatoes in the fall, followed by watermelons in the spring. The crops were irrigated at 0.75, 1.00 and 1.25 X ET. Immature compost delayed tomato plant growth due to N-rob. Tomato yield slightly increased above the control where mature compost was applied (fertilizer rates were equal). In the second year, a tomato yield equal to the control yield was obtained with 25% less N and K fertilizer where mature compost was applied. First-year watermelon yields were 54% and 33% greater where the high and low rates of Reuter compost were applied compared to the control (fertilizer rates were equal). Compost increased soil organic matter concentration, water-holding capacity, soil mineral concentrations, and pH in proportion to rate. The high rate of Reuter compost increased soil water content 33% above unamended soil. Bed soil water content was more uniform under drip irrigation with high compost rates.

16. Florida, Drs. Larry Parsons and Adaire Wheaton. Crops: Citrus. Hamlin orange trees were planted in soil treated with 0, 50 and 100 mt compost/ha. At another site, 49 mt compost/ha was soil incorporated, planted with Ambersweet trees and irrigated with reclaimed water. Hamlin trees showed no growth increase, but Ambersweet trunk diameters were increased by the compost during the first 9 months after planting. Root study revealed that the 50 and 100 t/ha compost treatment increased total root length and the concentration of roots at the 6 to 12 inch soil depth. Extractable minerals and pH were increased in the top 6 inch soil layer and the pH increased in the 6-12 inch depth. In the Ambersweet test, compost increased tree growth in the first year, but trees not receiving compost "caught up" in the second year. Soil water content was higher during the first year in the plots receiving compost, but there was no evidence of a water or fertilizer sparing effect of compost on tree growth. Leaf nitrogen was higher and leaf copper was lower the first year for plots receiving compost. The effects of compost on other leaf mineral elements were minor. The absence of a compost effect on tree growth after the first year may indicate that soil compost content declined to an ineffective level. Annual or more frequent compost applications may be required to maintain any growth benefit.

17. Florida, Drs. J.R. Rich and C.H. Hodge. Crops: Tomatoes. Addition of crab scrap compost suppressed root galling and the number of egg masses per plant, and generally increased foliar tomato growth. A minimum of 10 to 20% crab scrap compost was needed to suppress root galling and egg mass production. While crab scrap compost suppresses populations of M. javanica, it is much less effective than raw crab scrap. Effective nematode control with raw crab scrap has been reported.

18. Florida, Drs. Peter Stoffella and Nancy Roe. Crops: Tomatoes, peppers and cucumbers. Yard trimming/biosolids (YT) compost was incorporated at rates of 0 and 60 T/A with no fertilizer, 50%, and 100% of the grower's standard fertilizer in raised beds with polyethylene mulch. Bell pepper transplants were planted on January 20, 1994. Plots without fertilizer but with compost had taller plants with thicker stem diameters than plots without compost. Use of compost with no fertilizer increased marketable yields by 30%; with 50% fertilizer, yields increased by 11%; with 100% fertilizer, compost did not affect yields. Highest yields were in plots with 50% fertilizer and compost. Compost also decreased percent of culls. Tomato and pepper plants and cucumber seeds were grown in pots of soil, YT, or MSW compost. Plants in YT were larger after two weeks.

19. Hawaii, Deborah Ward. Crops: Urban horticulture. Recycle Hawaii Educators (8) received two one-day training sessions from CES staff (PI). They are now presenting public workshops at composting demonstration sties--3 across the Island. More than 250 people have participated in the past two months. The program has the financial backing of the County of Hawaii. The garden has doubled in size, and we are mulching with spoiled hay silage donated by local farmer. This year we needed micronutrient amendments in the garden.

20. Iowa, Drs. Jerald L. Schnoor and Louis A. Licht. Crops: Hybrid poplar trees, corn and fescue. Spiked compost was applied at 25 kg/m^2 on four small plots planted with corn, fescue, hybrid poplar trees, and a control. model and laboratory simulations were performed on leaching of PCB, DEHP (diethyl hexyl phthalate), benzo(a)pyrene, and chlordane. Cores were taken of each plot after one year and two years. DEHP was spiked at the highest concentration and provided the best signal. There was little vertical migration measured, although DEHP may have increased over time due to leaching from plastics in the unsieved compost. Biodegradation, volatilization, and sorption were important fate pathways.

21. Maryland, Dr. Frank Gouin. Crops: Fushia and bedding plants. Compost concentrations above 25% by volume continue to cause stunting despite extended maturation of five months.

22. Maryland, Dr. John Bouwkamp. Crops: Spinach. Application rates as low as 20 dry tons per acre killed spinach seedlings despite 2 side-dress applications of N at 60 lbs/A.

23. Maryland, Dr. John Bouwkamp. Crops: Pickling cucumbers. Application rates of 10 dry tons per acre of each increased cucumber production eight times and appears to be reducing nematode population.

24. Massachusetts, Dr. Allen V. Barker. Crops: Strawberries, blueberries, apples, landscape flowers, wildflower sod. Experiments with 100% composted layered on plastic were conducted in plots. Turfgrass (Lolium perenne 'Pennfine') and wildflowers (Northeast mix) were grown in the layers of compost. Year-old compost gave better growth of both crops than compost from the current season. High ammonium content restricted establishment of stands in biosolids compost from the Springfield plant. This problem was not encountered with the other composts, including the AllGro biosolids. Best growth occurred in the agricultural compost. This compost supplied an abundance of nitrogen but little ammonium. Leaf composts were too infertile to support crop growth without supplemental fertilization. Production of sods in composts directly applied to land at South Deerfield was successful but difficult because of emerging soil-borne weeds. Bloom of wildflowers was spectacular in summer 1993 and spring 1994. Outreach included demonstrations at local garden centers for wildflower production in sods.

25. Massachusetts, Drs. Daniel Cooley and Sonia Schloemann. Crops: Strawberries. Additions of composts to soil elevated the organic matter, CEC, plant nutrients (NO_3^-, P, K, Ca, Mg) and lowered the bulk density of the soil relative to the values recorded in untreated or fumigated (vapam) soil. Plant survival was unaffected by MSW compost, but was slightly lower with agricultural or leaf compost than with the fumigated or untreated controls. All composts slightly restricted runner growth.

26. Minnesota, Dr. Thomas Halbach et al. Crops: Corn/soils. Compost with C:N <20 had positive yield effect on corn. Compost with C:N >30 decreased yields.

27. New Hampshire, Drs. George Estes, John Halstead, Lawrence Hamilton, William McDowell and James R. Mitchell. Crops: Turfgrass and corn. Field experiments used soil incorporated MSW compost at rates of 0, 25, 50 and 100 T/A (dry weight basis) to grow silage corn and commercial sod. Measurements of soil properties (pH, cation exchange capacity, soil organic matter, soluble salts, nutrients and metals) were determined. Crop yield and tissue composition of nutrients and metals (Cd, Cu, Zn, Pb, Ni). Results showed production of commercially acceptable sod only at the 100 T/A rate of MSW compost. A nitrogen deficit at all rates 9 months post plant. No metal mobility was apparent beyond the zone of incorporation of MSW compost. Zinc was the only metal that showed significantly elevated levels of accumulation in corn beyond the normal range following soil incorporation of MSW compost. Soil properties (bulk densities, organic matter, CEC, water retention) were significantly improved with MSW compost use. Sociopolitical aspects of siting a MSW facility were determined by survey which identified six key "siting" principals.

28. New York, Dr. Vincent R. Breslin et al. Crops: Turfgrass, Kentucky bluegrass. A randomized grid was imposed on a 125' x 200' area which was subdivided into 20 25' x 50' blocks. Five treatments, 0, 10, 20 and 30 tons per acre MSW compost and 30 tons per acre of MSW-sewage sludge co-compost. In addition, 4 large plots 57' x 200' (2 control, 10 tons MSW compost/acre and 30 tons MSW compost/acre) were established parallel to the groundwater flow for groundwater quality studies. Application of the compost to the site was performed on June 12, 1992 using a top dressing machine and was seeded with Kentucky Bluegrass on June 13, 1992. The turfgrass seed in areas amended with compost was delayed in germination and vigor. However, by the end of July, 1992 there was sufficient germination of the seed in all treatments to continue with the initial seeding. As time progressed, quality and tensile strength of the sod for both treatment and control areas continued to improve. Recent surveys (May, 1994) of sod quality show that sod grown in soil and soil amended with MSW and MSW-sewage sludge composts have achieved acceptable sod quality and is ready for harvest. An enrichment of lead, cadmium, copper and zinc was measured in the upper 5 cm soil layer following application of the MSW composts. However, after 18 months, these elements remained confined to the upper 5 cm soil layer and did not accumulate in the turfgrass. Results of the groundwater monitoring during the past two years showed that there were no significant differences in water quality parameters between control wells and wells sampling groundwater under plots where MSW composts had been applied.

29. New York, Drs. John Peverly, Ken cobb and Cliff Scherer. Crops: Corn for grain and wine vineyard. Rates ranged to N equivalents of 200 lbs/acre, and yields were increased at all compost rates, compared to fertilized and unfertilized controls. Compost-derived nitrate formation was greater than hypothesized, and the overapplications resulted in shallow ground-water nitrate concentrations well above the 10 ppm standard, there were no detrimental effects on yield or crop quality, but compost treatments did increase zinc in tissues, and selenium and boron in groundwater compared to controls. Management based on compost N needs refinement. Community officials and citizens know there are risks, but feel uninformed as to technical issues or where to go for unbiased information. Focus groups continue to meet at the county level.

30. New York, Dr. Joe M. Regenstein. Crops: Marigold, radish, tomato and melon seeds. Mollusks composted well in weight ratios up to 1:1 with poultry litter, peat and sawdust mixture. Whole mussels and shells composted well. Seed germination of marigolds, tomatoes and radish comparable to top soil and no nutrient deficiencies found in young plants. No significant pH effects found in addition to top soil, though shells not greatly broken down in composting process. Post-composting grinding of compost may reduce shell size enough to see immediate liming effects. Shell fragments do not appear sharp in final soil-compost mixtures. Mussel and final compost heavy metal and PCB contamination very low.

31. North Carolina, Drs. Michael R. Overcash and Yutai Li. Crops: Lettuce, fescue, wheat, potato and peanut. The chemicals PCB and BaP were separately amended into MSW before composting process. The amended composts with 12.5, 25, 50, and 75% by volume were mixed with Norfolk soil and grown five plants. Soil samples were taken periodically to determine the decomposition of PCB and BaP. Plant samples were harvested and analyzed for plant uptake in parent form and in total 14C form. The loss of 10-30% of parent PCB and 40-70% of parent BaP were observed during the four month composting process. Highest concentrations were found in potato peel for both PCB and BaP due to direct contact to chemicals. Potato

core, wheat seed, and peanut nut were at background level. Lettuce, fescue and wheat shoot were found a ppb level of both chemicals. In general, due to strong bonding of both chemicals to soil particles especially soil organic matter, aboveground plant portion are safe in terms of the pollutant uptake studies.

32. Pennsylvania, Dr. Douglas Beegle. Crops: Corn. Significant yield response to adding compost was observed up to at least 5 years after application of compost. Some but not all response due to N in compost. Response from improvement in physical properties likely.

33. South Carolina, Drs. Richard K. White, R.W. Miller, Jr. and J.D. Ridley. Crops: Apple trees. Five years of application at three rates with chemical treatment and control. Applications annually and biannually. Significantly (at 95% level) reduces death loss to trees.

34. Virginia, Drs. Gregory Evanylo and Mark Schoebeck and Mrs. Archer Christian. Crops: Tomato. Tomatoes are being grown on farms in a variety of mulches - namely, black polyethylene, recycled paper, hay, yard waste compost, and bare soil - to compare their effects on soil biological (earthworm populations), physical and chemical properties and plant variables, i.e., leaf nutrient concentration and marketable yields. Yard waste compost was applied three inches thick as a mulch. Preliminary data indicate that soil moisture and temperature under the compost compares favorably with all treatments. After completion of fruit harvest in September to October, soil will be sampled and analyzed for bulk density and aggregate stability. Infiltration rate will be determined in the field. Soil samples will be tested for nitrate at flower initiation and subjected to routine soil testing analysis at the end of the season.

35. Washington, Drs. Charles Henry and Rob Harrison. Crops: Lettuce, potatoes, tomatoes, corn, fescue and beans. Experiments used 25, 50 and 75% by volume in field plots (30 cm depth) of three composts in two different soils and climates. Form of trace metals during composting and after use in the field 1 and 2 years later has been assessed. The majority of the metals are in residual forms and organically bound, with little exchangeable or soluble. Trace metal uptake has been assessed for two years. There appears to be little effect of application rate, or concentration in the compost; concentrations in the treated plants are similar to those grown in control soils. One exception exists: cadmium uptake in the compost amended with metal salts is generally much greater than the other composts and the control.

36. Wisconsin, Dr. Richard Wolkowski. Crops: Corn. 1993-94. Design: 0-40 T/a DM compost.Separate plots received 0-160 #/aN. Compost of 3 ages (each rate): Fresh (just out of vessel), 6 wk in turned pile, 36 wk (1st half in turned pile, remainder in static pile). Fresh and 6 wk compost decreased corn yield. Mature compost grain yield nearly equivalent to that where fertilizer applied on sand soil, slightly less on silt loam soil. Study repeated in 1994. 1993. Design: Compost applied at 0-48 T/a DM. Separate plot received equivalent nutrients as fertilizer. Measure yield, growth, nutrient content, soil NO_3. Compost slightly increased yield of corn grain and silage. Slight increase in silage Cr conc. No effect on grain metal conc. Soil nitrate levels were higher in plots receiving N fertilizer. Residual effects are to be measured in 1994.

37. Florida, Dr. Hans Riekerk. Forestry: Slash pine. Mature compost was applied at 0, 100, 200 and 300 dry ton per acre in a young forest plantation and on a cleared site during the fall of 1992. Seedlings were planted after soil incorporation the next winter, but suffered from deer browsing and insect damage. None survived the dense dogfennel weed competition on the treated plots. Trees in the young stand were remeasured during late summer of 1993, but did not show the expected growth response. Soil water had high nutrient increases proportional to compost loading rates. In groundwater only the 300 ton rate in the cleared site averaged 18 ppm nitrate-nitrogen with a peak of 70 ppm, delayed by ammonium-nitrogen conversions and slow water movement during the relatively dry year. The other rates and all those of the forest plantation on the average generated less than 2 ppm of nitrate-nitrogen in groundwater. Heavy metals were below detection.

38. Minnesota, Dr. T.J. Nichols. Forestry, red pine and white spruce. First year: Compost decreased growth on red pine; increased growth on white spruce. One source decreased herbaceous cover.

39. Connecticut, Dr. Brian Eitzer. Compost Properties, Volatile Organics: A study of volatile organic chemicals in the air at composting facilities was conducted. The study was aimed at targeted compounds (primarily those listed in EPA method 8240) and used thermal desorption GC/MS technology. A major group of chemicals present was identified as terpenes. The results indicated that the total VOC concentrations ranged from less than 10 to greater than 150 mg per cubic meter with most of the samples being between 10 and 50 mg per cubic meter. In most cases individual compounds were present at concentration levels well below ACGIH permissible exposure limits for indoor workplace air. The maximum concentrations were observed in the early stages of composting (i.e., on the tipping floor, near the shredders, and as the compost heats up). There were indications that ketones might be produced by the composting process.

40. Florida, Dr. Don Graetz. Compost properties: Chemical, physical and biological analyses. The extent of nutrient and metal release from compost-soil mixtures during aerobic incubation has been determined for four representative composts at rates representing 135, 270 and 540 metric tons/hectare. Initial (Day 0) NH_4-N concentrations in the leachate were relatively low (< 15 mg/L) and appear to reflect NH_4-N concentrations in the soil. With the exception of the Reuter compost from Clark, nitrifying bacteria converted the NH_4 to NO_3 within 14 to 21 days. The Reuter-Clark compost material immobilized both NH_4 and NO_3 during the initial week of incubation due to its high C/N ratio. Both Reuter compost and Reuter-Schaffer materials showed reduced concentrations of NO_3-N during the first week of incubation, suggesting some N immobilization. However, both materials subsequently produced considerable amounts of NO_3. The Reuter-Clark compost material (39:1 C/N) produced NO_3 at a lower, but more sustained rate than did the Reuter-Schaffer material (25:1 C/N). The Bedminster and Amerecycle composts contained relatively high concentrations of NO_3-N initially and concentrations tended to decrease with incubation time. Very low amounts of metals were released over the 12 week period of the experiment. Compost samples from Palm Beach Solid Waste Authority used with vegetable and container ornamental projects are sent to Gainesville for characterization. Two compost samples (uncured compost--yard waste/biosolids--and the same stored approximately two months) have been received. Water-soluble (saturated media extract) potassium, phosphorus and sodium concentrations averaged 480, 5 and 355 mg/L. Metal concentrations were generally less than 0.2 mg/L. Iron averaged 1.0 mg/L and Boron was 0.5 mg/L. Total K and P concentrations were 0.36 and 1.1%, respectively.

41. Florida, Dr. Roger Nordstedt. Compost properties: Co-composted shredded malaleuca and cow manure. Shredded malaleuca from Ft. Myers is being composted with fresh scraped cow manure from dairy farms in Okeechobee County. Initial experiments used 0, 10, 20 and 100% cow manure by volume in piles which were approximately 33 cubic yards in volume. They were turned and mixed with a tractor loader, since a windrow turning machine was not yet available at the site. Initial moisture content ranged from 64.9% for the 100% cow manure and 49 to 55.7% for the malaleuca/cow manure mixtures. Initial temperatures of the compost piles were approximately 23°C and the initial oxygen content of the malaleuca/cow manure mixtures was approximately 20%. Temperatures in all of the piles which contained cow manure reached at least 55°C. The pile of malaleuca which contained 0% cow manure showed some heating tendency, but the highest temperature recorded was only 39°C. Additional experiments are planned. The compost products will be made available for crop production experiments.

42. Illinois, Dr. Michael A. Cole. Compost properties, pesticide degradation: Compost was used to amend pesticide-contaminated soil. Compost increased plant growth, fungal and bacterial populations, microbial activity, and accelerated pesticide degradation. Completed work was done in the greenhouse and we are currently looking for a site at which to conduct a field-scale pilot study. Funding sources: Illinois Hazardous Waste Research and Information Center and Solum Remediation Services. In previous work, we measured toxic metals and other compounds of environmental concern in compost and leachate in composting yard waste when the yard waste was mainly grass clippings and brush. In this study, the major component of the composting yard waste will be fall-collected leaves. Samples of pond sediment adjacent to the composting site are being analyzed for toxic metal content in an attempt to determine whether or not long-term use of the site results in increased toxic metal content off-site. Funding sources: Illinois Dept. of Energy and Natural Resources and DK Recycling Systems, Inc.

Crop--Various grasses--(New Project) Techniques used by soil scientists to estimate mineralization of soil organic matter, which releases N and P for plant growth, will be evaluated for their utility in estimating plant available N and P from compost. Results will be valuable to compost users who need to know how much N and P the compost can provide for plant growth. Funding Source: U.S. Dept. of Agriculture (Hatch).

43. Minnesota, Dr. Paul R. Bloom and Bruce Cook. Compost properties, herbicide fate. Initiating studies on the fate of herbicides (atrazine, trifluralin and 2,4-D) during composting. Mineralization, volitilization and percent material/metabolite measurements will be used to determine if composting enhances the rate of herbicide degradation, and if it could be used as an inexpensive, low-tech method for the detoxification of herbicides in unused solutions, soil, water and yard waste.

44. Ohio, Drs. Jodi R. Shann and J. Robie Vestal and Ron Herrmann. Compost properties, microbial communities. Microbial enzyme activities and phospholipid fatty acid (PLFA) profiles were followed across the composting process. Composting was conducted at a full-scale (Recomp) and at a pilot-scale (P&G) facility. The full-scale feed material was always MSW, while either MSW (transported from Recomp) or a synthetic material was used in the pilot-scale runs. Several enzymes exhibited patterns that might be useful as indicators of compost maturity. Fatty acid profiles (relative lipid groupings) proved to be highly consistent across the different composting runs. Specific PLFAs clusters appear early in the process, during active phases, and while curing. In general, these clusters were found in the full-scale and pilot-scale, regardless of the feed materials used. Process problems could also be discerned by the unexpected appearance of distinctive PLFAs.

45. South Carolina, Dr. Richard K. White. Compost properties, landfill cover. Evaluating material as to its suitability for daily landfill cover.

Conclusion

This effort confirmed that there is a growing body of research addressing several important compost parameters and utilization opportunities. Several projects have revealed that stable and mature composts, properly applied, can result in benefits to the utilization system.