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Compost Maturity Effects on Nitrogen and Carbon Mineralization and Plant Growth

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Improved predictive relationships between compost maturity and nitrogen (N) availability are needed. A total of 13 compost samples were collected from a single windrow over a 91 d period. Compost stability and maturity were assessed using both standard chemical analyses (total C and N, mineral N, total volatile solids) and other methods (CO_2 evolution, commercial maturity kits, and neutral detergent fiber, and lignin). Compost N and carbon (C) were evaluated during a 130 d aerobic incubation in a sandy loam soil after each compost was applied at 200 mg total kg^{-1} soil. The effect of compost maturity on plant growth was evaluated by growing two ryegrass (*Lolium perenne* L.) crops and one barley (*Hordeum vulgare* L.) crop in succession in compost-amended soil under greenhouse conditions. Potential phytotoxicity from compost was assessed by growing tomato (*Lypersicum esculentum* L.) seedlings in compost-amended soil. Regression and correlation analyses were used to evaluate the relationship between compost maturity parameters, the rate and extent of net N and C mineralization, plant yield and N uptake, and phytotoxicity. Commonly used maturity parameters like total C, total N, and C:N ratio were poorly correlated with the rate and extent of mineralization, and with plant growth parameters. The N mineralization rate during the first 48 d of aerobic incubation was strongly correlated (r= -0.82 to -0.86) to compost fiber and lignin concentration, and to the Maturity Index (r=0.85). Trends in C mineralization were similar. There were few differences in C mineralization between composts after 48 d of aerobic incubation in soil. Ryegrass harvested 35 and 70 d after compost application was not strongly affected by compost maturity, and relatively immature composts were phytotoxic to tomato seedlings. Methods of characterizing compost maturity and stability that more realistically reflect the composting process are better predictors of N release and potential plant inhibition after incorporation into soil.

Introduction

There are many compositional changes that occur during the composting process, and these can be used as indices of compost *maturity* as it relates to nutrient availability, or of compost *stability* and associated effects on plant growth (Cooperband *et al.* 2003; Ozores-Hampton *et al.* 1999). Simple chemical measurements like total N or C:N ratio have been widely used, but the relationship between these constituents, the composting process, and the suitability of the compost for plant media have not been very robust (Brewer and Sullivan 2003; Cambardella *et al.* 2003). Other approaches to evaluating composts, as discussed by García-Gomez (2005), include microbial activity, the concentration of biodegradable fractions, and the extent of humification. Microbial activity is quantified as microbial CO_2 respiration from the compost under standardized conditions (Brewer and Sullivan 2003; Wang *et al.* 2004). Potentially biodegradable substrates that have been used include water soluble C (García-Gómez *et al.* 2005) and dissolved organic C (Zmora-Nahum *et al.* 2005). Alternatively, quantification of the slowly- or nondegradable substrates in compost includes humic and fulvic acid content (Adani *et al.* 1999; Bernal *et al.* 1998b; Francou *et al.* 2005; García-Gómez *et al.* 2005).

There are few evaluations of the ability of compost characteristics to predict C and N mineralization in the soil, or plant growth and N uptake. The aerobic incubation experiments conducted by Bernal *et al.* (1998b) demonstrated that more N and C would be mineralized from sewage sludge compost that was not yet stable, without establishing a quantitative relationship between compost characteristics and C mineralization parameters. Similarly, Bernal *et al.* (1998a) found that more than 25% of compost total organic C (TOC) could be mineralized during a 70d aerobic incubation for immature composts from a range of feedstocks. The aerobic incubations conducted by Hadas *et al.* (1996) are similarly descriptive in nature, evaluating the impact of compost application rate and prior soil amendment on compost C and N mineralization.

When incorporated into the soil, further decomposition of compost substrates can inhibit plant growth, independent of the availability of nutrients from the compost. Ozores-Hampton *et al.* (1999) found that municipal solid waste composted for 3 to 56 d could inhibit germination and growth of both weed and crop species, compared to 1 yr old compost, which may have been due to high concentrations of volatile fatty acids in the immature materials. Zmora-Nahum *et al.* (2005) demonstrated that different compost types could inhibit growth of ryegrass (*Lolium perenne* L.) and cucumber (*Cucumis sativus* L.) if incorporated into soil when immature, arguing that compost stability is evident when dissolved organic C (DOC) concentration stabilizes. They did not document the correlative relationship (if any) between plant growth parameters and DOC. In a bioassay also using cucumber seedings, Wang *et al.* (2004) found that plant dry weight increased as composting duration increased for dairy manure+straw compost and dairy manure+sawdust. They also demonstrated that many characteristics of the dairy manure+straw compost were significantly correlated with seedling growth (e.g. C:N, electrical conductivity, composting duration in days), but not for the other two composts evaluated.

We utilized samples from a single compost windrow, to avoid the confounding effects of different feedstocks, to evaluate decomposition in soil and potential impacts on plant growth and N uptake. Specifically, the objectives of this research were to: 1) assess compost N and C mineralization during the course of an aerobic incubation in soil; and 2) evaluate the relationship between compost characteristics, N and C mineralization parameters, and plant growth.

Materials and Methods

Compost Sample Collection and Characterization

A single compost windrow at a commercial composting site in Thorndike, Maine, was sampled 13 times over a 91 d period. Sampling began 18 d after windrow formation; prior to sampling, the temperature in the windrow fluctuated between 54 and 77°C for 15 consecutive days, during which the windrow was turned five times. Initial feedstocks included fish processing residuals, dairy heifer bedding, waste silage, and wood shavings. On each sampling date, subsamples were collected from the 30-90 cm layer of the windrow at four locations. The subsamples were composited, mixed well, and a 4 L sample was retained and frozen until analysis. The windrow was actively composting (temperature at 30 cm depth > 40°C) during the entire 91 d collection period.

Characterization of the composts included both chemical and biological parameters, as follows:

- Total solids (TS), drying at 105°C for 24 hr.
- Total volatile solids (TVS), combustion at 550°C for 3 h.
- Organic N concentration in the fresh sample was estimated as the difference between total Kjeldahl N (Kane 1998) and NH_4 concentration determined by distillation of NH_4 with MgO (AOAC Method 973.49).
- Neutral detergent fiber (NDF) (Mertens 2002) concentration, using an automated Ankom 200 Fiber Analyzer (ANKOM Technology, Fairport, New York).
- Lignin concentration, (Robertson and Van Soest 1981), digestion of NDF residue in 12 M H_2SO_4.
- Total C concentration, by thermal conductivity detection following combustion at 1650°C, on a CE Instruments NA2500 Elemental Analyzer (ThermaQuest Italia S.p.A., Rodano, Italy).
- Compost stability, by CO_2 evolution from 25 g (fresh weight) sample during 24 hr incubation in a sealed 1 L glass jar (Changa *et al.* 2003). A 1 *M* NaOH trap was used to capture CO_2, which was then titrated with standardized 1 *M* HCl (Zibilske 1994).
- Compost maturity, using the Solvita Maturity Index (Woods End Lab, Mt. Vernon, Maine), which qualitatively assesses CO_2 and NH_3 evolution from compost by color changes in paddles, which are enclosed with the sample for 4 hr period.

The linear relationships between concentration of C, N fractions, NDF, and lignin in these composts, and the duration of the composting period, was substantially improved if these constituents were calculated as a proportion of TVS, rather than a proportion of TS or dry matter (data not shown). Accordingly, all compost parameters are on a TVS basis in the assessment of the effect of compost maturity on mineralization and plant growth presented here.

Aerobic Incubation for Compost N and C Mineralization

Compost N and C mineralization were evaluated during an aerobic incubation in sandy loam soil (Nokomis sandy loam; coarse-loamy, mixed, frigid Typic Haplorthod). The soil was obtained from the 0-15 cm layer of a tilled field at the USDA-ARS research site near Newport, ME. Initial soil phosphorus (P) and potassium (K) levels, as determined by the modified Morgan extraction (McIntosh 1969), and inductively coupled plasma emission spectroscopy (ICP) were equivalent to 321 and 7 kg ha^{-1}, respectively. Total C and N concentration in the soil was 25.2 and 2.1 g kg^{-1}, respectively, determined by thermal conductivity detection following combustion at 1650°C. Soil pH (1:1 slurry, soil:water) was 5.9, and soil CEC was 4.6 meq

100 g^{-1}. Particle size distribution of sand, silt, and clay, estimated using the sieving method of Kettler *et al.* (2001), was 520, 400, and 80 g kg^{-1}, respectively The bulk soil was sieved (2 mm) while still field-moist, and stored at 4°C until needed.

The aerobic incubation protocol of Griffin *et al.* (2005) was used to evaluate compost N and C mineralization, with minor modification. Prior to beginning the incubation , soil (250 g, dry weight equivalent) was weighed into 1 L glass jars. The soil was packed to a density of 1.1 g cm^{-3}. All containers were preincubated at 25°C for 10 d before amendment with compost.

At *time* = 0, each compost was added to triplicate jars of soil at a rate of 200 mg total N kg^{-1} dry soil, along with sufficient deionized water to increase soil water content to 0.25 kg kg^{-1}. The resulting water filled pore space (WFPS) of approx. 60% was maintained throughout the entire incubation period. The soil + compost mixture was thoroughly stirred for 30 sec with a small stainless steel spatula. An unamended control treatment (*i.e.* no compost added) was processed in the same manner. A 12.5 g sample (approx. 10 g dry soil equivalent) was taken from each container immediately after mixing. This subsample was placed in a 100 mL container with 50 mL of 2.0 *M* KCl, shaken for 1 hr, and centrifuged (2 700 * *g* for 10 minutes). The supernatant was decanted, and used to determine initial (t = 0) concentration of NO_3 and NH_4. Immediately after sampling, the soil was repacked to the initial density, and the container was capped. Soil NO_3 and NH_4 concentrations were determined for each vessel 7, 14, 20, 36, 48, 64, 92 and 130 after initiation, using a 6 g subsample and 25 mL of 2 *M* KCl. At each sampling time, soil was quickly stirred, sampled, and repacked. Extraction and N determinations were as on t = 0. All containers were aerated for 1 hr d^{-1} for the first 2 wk, and 1 hr every 2-4 days thereafter. Soil water content was adjusted periodically throughout the incubation period to maintain 60% WFPS, accounting for changes in soil mass and volume.

Net N mineralization (N_{min}) at each sampling time (t) was calculated as:

$$N_{min}\ (\text{mg kg}^{-1}\ \text{soil}) = [N_i]_t - [N_i]_{t=0} \qquad (1)$$

where N_i is the sum of NO_3 and NH_4 at time, t (Griffin *et al.* 2005).

Both linear and exponential models have been applied to cumulative N mineralization from soil amendments, including either one or two N pools (Bernal *et al.* 1998a; Bernal *et al.* 1998b; Chèneby *et al.* 1994; Francou *et al.* 2005). We applied each of these models to our incubation data during preliminary analysis (data not shown). Although all of these models were satisfactory in describing net N mineralization over time, the simplest model fitted to these data was a combination of two zero-order (linear) functions, representing the early (< 50 d) and later (50-130 d) phases of the aerobic incubation. Equations were fit using all data points (not mean values), and parameters were estimated using the linear regression module of SYSTAT, Version 10.0 (SPSS Corp., Chicago IL).

Measurements of C mineralization were not taken continuously during the incubation. Instead, an alkaline CO_2 trap (5 mL of 1 *M* NaOH) was placed in each incubation jar for the 24 hr period *preceding* each soil N sampling data. This resulted in discrete C mineralization rate estimates for each sampling period, during the first half (64 d) of the incubation. The C mineralization rate declined rapidly for all composts during this phase of the incubation, and the change in C mineralization rate over time could be modeled by the exponential decay function

$$\text{C mineralization rate (mg } CO_2\text{-C kg}^{-1}\text{ soil d}^{-1}) = Y_0 + a * e^{(-b*t)} \qquad (2)$$

where Y_0 is the asymptotic limit representing non-degradable C, a is the mineralization rate at first sampling (t=7 d), b is rate constant, and t is time, in days.

An approximation of the amount of CO_2 released during the period of sampling (7 to 64 d after amendment) was obtained by integrating the area under the curve defined by the decay function above, for each compost treatment. Mineralization of compost C was calculated as the difference in CO_2 released from amended and unamended soil.

Effect of Compost Maturity on Plant Growth

A greenhouse pot experiment was conducted to evaluate the effect of compost maturity on plant growth. This greenhouse growth experiment used the same soil and composts as above, and successive crops of ryegrass (*Lolium perenne* L., two harvests) and barley (*Hordeum vulgare* L.). Soil (400 g, dry weight equivalent) and composts were mixed at the same rate as in the aerobic incubation, and transferred to a 10 cm diameter greenhouse pot; there were three replicates per treatment. Ryegrass seed (approx. 2 g) was distributed on the surface, covered with 1 cm additional soil/compost mixture, and lightly packed. Two additional control treatments were included; N Minus (which received P and K equal to the average application rate of all of the compost treatments), and N Plus (P and K as in N Minus, plus N fertilizer at rate of 15 mg N kg^{-1} soil $week^{-1}$ for duration of plant growth). Pots were watered every 1-3 d, with soil water content estimated by weighing pot plus soil/compost mixture. Supplemen-

tal full-spectrum lighting was used to maintain a 16 hr photoperiod, with minimum intensity of 300 μE PAR m^{-2} sec^{-1}, with a temperature range of 15 to 27°C. Ryegrass was harvested at 35 and 70 d after planting, by cutting at 2.5 cm above soil surface. Plant material was dried (48 hr at 50°C), ground, and analyzed for total N. Above-ground crop N removal was calculated as product of dry matter yield and N concentration. After two growth cycles, ryegrass was killed by application of glyphosate [*N*-(phosphonomethyl)glycine]. The soil in the pot was loosened, and the root mass of the previous ryegrass crop was removed. Six barley seeds were then spaced evenly in each pot. Barley was harvested while still vegetative, 30 d after planting. For yield, N concentration, and N removal, treatment differences were identified by Analysis of Variance.

Because some treatments resulted in stunted ryegrass in first growth cycle (see Results), we conducted a greenhouse experiment to directly evaluate potential phytotoxicity from composts. Each compost was mixed with soil (same rate as above) and distributed to five greenhouse seedling plugs (6 cm deep by 4 cm diameter). Two tomato (*Lypersicum esculentum* L.) seeds were placed in each plug, and covered with 1 cm soil/compost mixture. Seedling emergence was assessed daily beginning 3 d after planting. At 15 d after planting, when emergence was complete, the combined height of seedlings in each plug was measured; this accounts for differences in emergence and early growth.

Relationship of Compost Characteristics, Mineralization Parameters, and Plant Growth

Because the composts were produced from the same initial feedstocks, the information gained from standard statistical evaluations like Analysis of Variance is minimal. Our principle interests were to assess the relationship between compost characteristics, N and C mineralization, and plant growth, and also to identify a subset of compost characteristics that were most strongly related to these other parameters. In most cases, simple linear correlations were sufficient to accomplish this goal. The relationship between mineralization and plant growth parameters, and the duration of the composting period was evaluated using linear regression. Both Cooperband *et al.* (2003) and Ozores-Hampton *et al.* (1999) distinguished between compost *stability* as it relates to nutrient bioavailability and compost *maturity* as it relates to plant growth. In this regard, our incubation experiment assessed compost stability, while the greenhouse experiment assessed compost maturity.

Results and Discussion

Compost Stability and N and C Mineralization

All 13 composts resulted in net N mineralization in sandy loam soil, compared to the unamended control soil. Much of the difference in cumulative net N mineralization between composts resulted from differences in N mineralization rate during the Early phase of the incubation, with shorter composting duration resulting in more rapid N mineralization. Samples that had been composted for 38 (sample CNM 4) and 95 (CNM 11) d are used to illustrate the effect of compost stability, as shown in Figure 1. The sample that had been composted for 38 d had a net N mineralization rate of 0.92 mg N kg^{-1} soil d^{-1} during the early phase (7-48 d) of the incubation, compared to 0.46 mg N kg^{-1} soil d^{-1} for the sample composted for 95 d *and* the unamended control soil.

Net N mineralization rates during the Residual phase were similar for most composts, and for the unamended control soil. The relationship between net N mineralization rate (during each phase of the incubation) and the duration of the composting period is shown in Figure 2; there is a significant linear relationship for the Early N mineralization rate, but no significant relationship with the Residual N mineralization rate. The aerobic incubation experiments of Benitez *et al.* (2003), Hadas *et al.* (1996), He *et al.* (2000), and Nendel *et al.* (2004) all had similar findings, in that the accumulation of inorganic N was rapid for a short period after adding compost to soil, and then much slower for the remainder of the incubation. There are few previous reports, however, that evaluated the effect of compost stability on N mineralization in soil without confounding stability and compost feedstocks. The linear correlations between compost sta-

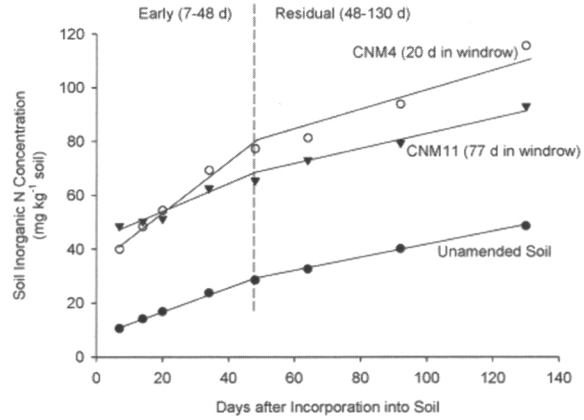

FIGURE 1. Net N mineralization from two composts (composted for 38 and 95 d) and from unamended sandy loam soil during aerobic incubation at 25°C.

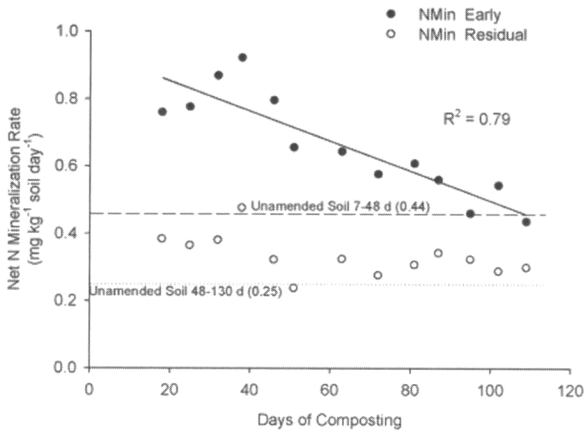

FIGURE 2. Relationship between duration of composting period and net N mineralization from composts incubated in sandy loam soil.

bility parameters and N mineralization parameters from the incubation are shown in Table 1. There were a number of compost stability parameters that were highly correlated ($P < 0.001$) with N mineralization rate (Early), including NDF, lignin, compost respiration rate, and the Solvita Maturity Index. All of these parameters had correlation coefficients (r) between 0.80 and 0.90 (most of the correlations were negative, except for the Solvita Maturity Index). It is notable that the strongest correlations with early N mineralization are with characteristics that would be expected to *limit* the rate and/or extent of mineralization, including fibrous components (NDF) and lignin. There were few examples of significant relationships between any of the compost stability parameters and 1) N mineralization in the Residual phase of the incubation, and 2) the proportion of compost organic N that was mineralized during the entire incubation. This suggests that differences in the amount of N mineralized are related to the pool of readily-mineralizable N in the composts, which becomes smaller as composting continues. The two compost constituent ratios (C:N and C:Organic N) that we included were weakly correlated with N mineralization (r = -0.72 and -0.57, respectively).

These results are consistent with our understanding of the biology of the composting process; the longer the active composting phase, the smaller the pool of readily-mineralizable N (which would be preferentially utilized by microbes during composting). The changes in the size and composition of this pool are reflected in the more rapid N mineralization rates for unstable composts. The recalcitrant pool of compost N would not be expected to change substantially during active composting, although the size of this pool relative to remaining organic matter would increase (Adani *et al.* 1999), which would be a component of both unstable and stable composts. The decomposition of this pool could be controlled by association with highly recalcitrant aromatic compounds, including lignin.

The C mineralization data from our incubation is discontinuous (taken only for discrete time periods during the first half of the aerobic incubation) but informative. The largest differences between compost samples were seen during the first two sampling periods (6-7 d and 13-14 d after incorporation). This is illustrated in Figure 3, for two samples subjected to 51 and 109 d of active composting. For the first sampling interval, the shorter composting period (labeled CNM6 in Figure 3) resulted in C mineralization approximately 3-fold greater than the longer composting period (CNM13), after subtracting CO_2 release from unamended soil. The difference was much smaller at second C sampling period, and all composts were very similar beyond 35 d. Numerous other incubation experiments have documented this same rapid decline in C mineralization rate from composts (Bernal *et al.* 1998a; Bernal *et al.* 1998b; Cambardella *et al.* 2003; Hadas *et al.* 1996), representing the rapid decomposi-

TABLE 1.
Pearson correlation coefficients between compost characteristics and N and C mineralization parameters from a 130 d aerobic incubation of composts in a sandy loam soil.

	Days	C:N	C: Org. N	NDF	Lignin	CO_2 Evolution	Solvita MI
				r			
N Mineralization							
7-48 d rate	-0.890***	-0.718*	-0.570*	-0.864***	-0.817***	0.800***	-0.851***
48-130 d rate	-0.530	-0.252	-0.134	-0.454	-0.565*	0.517	-0.331
Org N min.	-0.558*	-0.423	-0.125	-0.461	-0.417	0.608*	-0.668**
C Mineralization							
Rate, Day 7	-0.949***	-0.691**	-0.662**	-0.882***	-0.885***	0.829***	-0.730**
Rate, Day 14	-0.885***	-0.556*	-0.512	-0.821***	-0.834***	0.774***	-0.583*
Cumulative C	-0.852***	-0.484	-0.564*	-0.695**	-0.775***	0.865***	-0.482

*, **, *** are significant at 0.05, 0.01, and 0.001 level of probability, respectively.

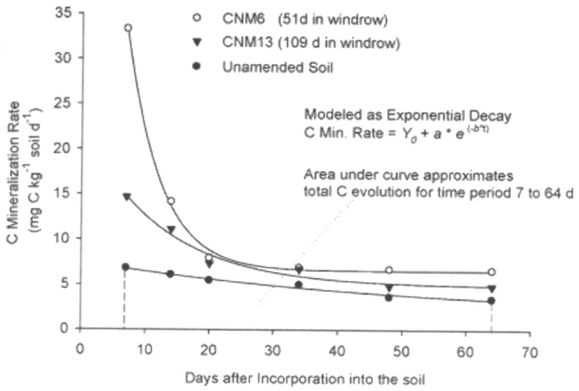

FIGURE 3. Changes in compost C mineralization rate from two composts (composted for 51 and 109 d) and unamended sandy loam soil during aerobic incubation at 25°C.

tion and eventual depletion of readily available C in the substrate. As noted above for N mineralization, the large pool of recalcitrant C in all of the composts is responsible for the stabilization of C mineralization rate after approximately one month, at levels similar to or slightly greater than that of unamended soil.

In addition to comparing compost treatments at each sampling date, we approximated the amount of C mineralized during the period 7-64 d after compost incorporation, by integrating the area under the curves (see Figure 3) defined by an exponential decay equation [Equation 2]. The relationship between estimated cumulative C mineralization during this period, and the duration of the composting period is shown in Figure 4. Although a linear relationship between these two variables provides a reasonable fit, a curvilinear function is superior and is biologically relevant; after active composting, there is not sufficient C remaining as substrate for thermophilic microbes. Beyond this point, the changes in the composition of compost C pools are small, as are difference in C mineralization when the compost is incorporated into soil.

The linear correlation coefficients for compost characteristics versus C mineralization parameters (C mineralization rate at 7 and 14 d after incorporation, and estimated cumulative C mineralization for 7-64 d) are shown in Table 1. The duration of the composting period is strongly (negatively) correlated with C mineralization rate and extent, as are parameters that quantify the recalcitrant C pools in the compost, again including both NDF and lignin. The rate of CO_2 evolution from the compost is also strongly correlated with these parameters, as it is also indicative of the degradability of C substrates. Both C:N and C:organic N ratios were correlated with C mineralization rate early in the incubation (first sampling period), but poorly or not at all for other parameters. Likewise, the Solvita Maturity Index was correlated with the C mineralization rate early in the incubation, but not with estimated cumulative C mineralized; it is likely that the Solvita test is more suited to evaluating the readily-degradable C and N pools in compost (*i.e.* characteristics of composts that are not stable).

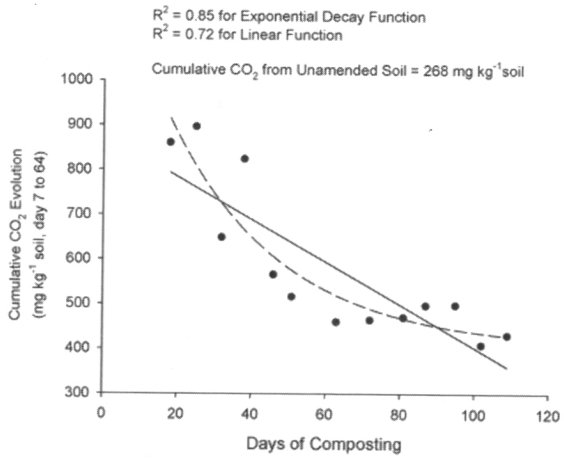

FIGURE 4. Relationship between duration of composting period and estimated cumulative C mineralization from composts incubated in sandy loam soil.

Compost Maturity and Plant Growth

The aerobic incubation experiment discussed above clearly demonstrated that prolonging the composting period resulted in slower mineralization of both N and C from the composts. The results of our greenhouse experiments confirm that the decomposition of compost substrate in the soil can have multiple impacts on plant growth, beyond nutrient availability.

Two successive harvests of ryegrass were conducted; the ryegrass had been planted immediately after composts and soil had been mixed. For both the first harvest (Figure 5) and second harvest (data not

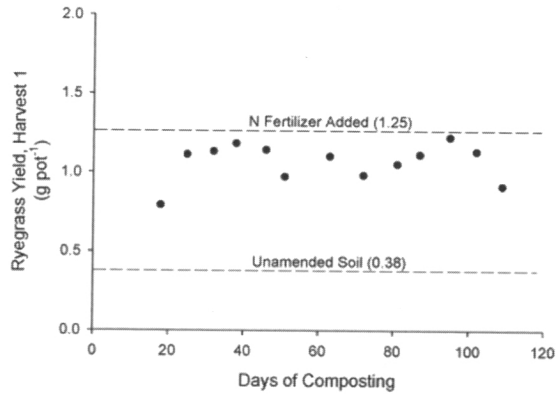

FIGURE 5. Relationship between duration of composting period and dry matter yield of ryegrass grown after incorporation of compost into sandy loam soil (first crop harvest, growth period 0 to 35 d after incorporation).

shown), the addition of composts generally increased plant biomass, compared to soil with no N applied (N Minus treatment). However, there was no relationship between the duration of the composting period and plant biomass, indicating that either 1) there was sufficient N supply from all compost treatments, or 2) factors other than N were limiting plant growth during these growth periods. We did not observe a dramatic reduction in plant growth for samples that had limited composting time, as seen by Zmora-Nahum *et al.* (2005); however, because *all* compost treatments resulted in plant yield less than the N Plus fertilizer treatment, the first alternative is less likely than the second.

The yield of the third successive crop (barley) grown in compost-amended soil *was* significantly related to the duration of the composting period (Figure 6). All of the composts resulted in lower biomass than the N Plus control, and most were less than the N minus control (indicative of net N immobilization). Longer composting periods resulted in lower biomass. These results are supported in part by the aerobic incubation, where N availability declines as the composting duration increases. Additionally, the phytotoxic effects of compost decomposition in the soil would be associated with the rapid breakdown after incorporation into the soil.

Several of the most immature composts (composted for 31 and 38 d) were clearly phytotoxic, significantly reducing tomato seedling growth after incorporating the composts into soil (Figure 7), compared to unamended soil and some later composts. The relationship between compost characteristics and plant yield, N uptake, and seedling growth is summarized in Table 2. Again, both NDF and lignin were significantly correlated with plant growth parameters, but only for the later harvests. Both were also *positively* correlated with tomato seedling growth, again indicating that it is the decomposition of more readily-

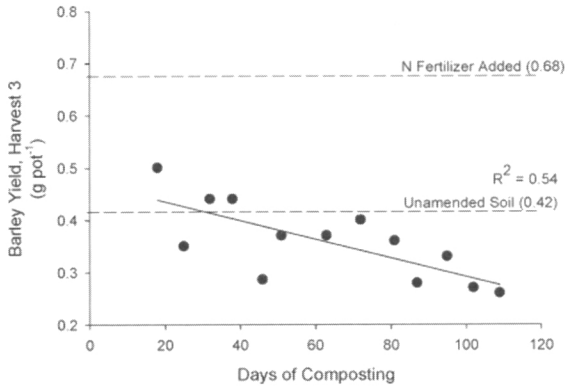

FIGURE 6. Relationship between duration of composting period and dry matter yield of ryegrass grown after incorporation of compost into sandy loam soil (third crop harvest, growth period 70 to 100 d after incorporation).

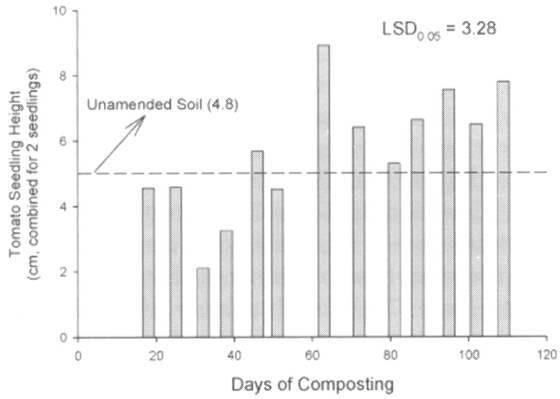

FIGURE 7. Relationship between duration of composting period and cumulative height of two tomato seedlings grown after incorporation of compost into sandy loam soil.

TABLE 2.
Pearson correlation coefficients between compost characteristics and plant growth and N uptake in the greenhouse.

	Days	C:N	C: Org. N	NDF	Lignin	CO_2 Evolution	Solvita MI
				r			
Plant Biomass							
Harvest 1	0.138	0.197	0.348	-0.016	0.297	-0.018	-0.211
Harvest 2	-0.186	0.021	-0.510	-0.713**	0.139	0.263	-0.361
Harvest 3	-0.739**	-0.546*	0.221	-0.171	-0.816***	0.481	-0.349
Total	0.324	-0.133	-0.340	-0.636*	-0.139	0.303	-0.474
Plant N Uptake							
Harvest 1	-0.175	-0.044	0.298	-0.043	0.061	0.276	-0.494
Harvest 2	-0.364	-0.180	0.161	-0.204	-0.027	0.391	-0.531
Harvest 3	-0.787***	-0.564*	-0.509	-0.760**	-0.861***	0.583*	-0.365
Total	-0.688**	-0.427	-0.121	-0.568*	-0.545*	0.616*	-0.628*
Seedling Growth	0.706**	0.684**	0.603*	0.736**	0.781***	-0.645*	0.606*

*, **, *** are significant at 0.05, 0.01, and 0.001 level of probability, respectively.

available compost substrates that results in the release of phytotoxic substances in soil. The remaining compost characteristics (C:N, C:organic N, CO_2 evolution, and Solvita) were either weakly correlated or not related to plant growth and N uptake in the greenhouse. Wang *et al.* (2004) found that these same parameters were strongly related to seedling growth for dairy manure+ straw compost, but not for two other compost types evaluated.

Conclusions

The changes that occur during the active composting phase clearly influence the mineralization of both N and C when composts are incorporated into the soil. While all of the composts evaluated here supplied plant-available N, with the amount of PAN declining as the length of the composting period increased, the release of phytotoxic compounds during decomposition made some of these composts less suitable as nutrient sources. Two compost characteristics that were consistently correlated with mineralization were NDF, a measurement of cell wall material commonly used in ruminant nutritional analysis, and lignin, a highly recalcitrant compound that is one component of NDF (the others being cellulose and hemicellulose). As composting proceeds, these two parameters make up a larger *relative* proportion of compost organic matter. They are not being formed during thermophilic decomposition, but are decomposing at a much slower rate than are the more soluble C and N pools. This is also reflected in the relationship between compost CO_2 evolution and the mineralization of compost N and C in the soil. As the duration of composting is extended, the remaining compost OM is less susceptible to decomposition, to the point that the composting process can not be sustained. The decomposition of this material by soil microbes is likewise much slower. In addition to being strongly related to the duration of the composting period and strongly correlated with N and C mineralization, these three parameters are consistent with the changes expected during the composting process.

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Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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