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Improving the Fertilizer Value of Cattle Manure for Sustaining Small Holder Crop Production in Ghana

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Abstract: A study was conducted through composting to evaluate the potential of *Chromolaena odorata*, *Stylosanthes guianensis* and maize stover mixture as sources of nutrients, for improving the fertilizer quality of cattle manure. Composting was done in a ratio of 1:1 and 2:1 plant materials mixture: manure. Mass loss and nutrient release from the composts were determined, using the leaching tube and litter bag techniques, respectively. Decomposition and nutrient release constants were estimated by fitting a single exponential model to the data. Composting significantly improved the nutrient content of cattle manure and thus its fertilizer value. The N content for instance was increased by 53 and 102%, respectively for the 2:1 and 1:1 composts which, suggests that the composting materials are potentially good organic amendments for improving the fertilizer value of cattle manure. Peak total N mineralization rates for the 1:1 and 2:1 compost types were observed on the 6th and 4th week of incubation, respectively. The association between C: N ratio and N and P releases were positively correlated with R-squared values of 0.33 and 0.35 and 0.70 and 0.74 for N and P respectively of the 1:1 and 2:1 compost types. The 2:1 compost had a higher decomposition rate ($k = 0.02$) than the 1:1 compost ($k = 0.03$) and half-life values were 35 and 23 days for the 2:1 and 1:1 compost types, respectively. This suggests that any of the compost types can be effectively used together with or without a small amount of mineral fertilizer to produce maize, which is a major cereal in Ghana.

Key words: Compost, cowdung, mineralization, immobilization, fertilizer

INTRODUCTION

Smallholder farms in many regions of sub-Saharan Africa exhibit a large degree of soil heterogeneity. Consequently soil fertility restoration was achieved by small holder farmers in the past through long fallow periods and clearance of new lands. The threats of climate change and increasing demand for land as a result of population increase has however, led to a breakdown of these soil fertility maintenance strategies (Sanchez *et al*., 1997). The result is that farmers are now moving to marginal lands such as degraded lands and those with high acidity and also forest reserves, which are more susceptible to erosion. Although the use of mineral fertilizers is recognised as the convenient way for rapid correction of nutrient deficiencies in soils, its high cost limits its wide application by farmers (Gerner *et al*., 1995). Thus farmers are unable to apply the needed quantities of mineral fertilizers to replace the nutrients that are removed by crop harvest. Even when the goals established by the African summit are realised (IFDC, 2006), the application of 50 kg nutrients per hectare is very moderate compared to the quantity of nutrients needed under intensive crop production.

Given the high cost and uncertain accessibility of inorganic fertilizers, farmers have over time found widespread use of locally available forms of organic nutrient sources such as livestock manures, green manures, composted materials and household waste and crop residues for crop production. Deceasing crop yields on farmers fields however, suggest that these organic inputs have low nutrient concentrations with limited potential to improve crop yields when applied as sole source of nutrients (Vanlauwe *et al*., 2006), resulting in negative nutrient balances (Rhodes, 1995; Sanchez *et al*., 1997). Recent studies by Fening *et al*. (2005) showed that the N and P concentrations of cattle manure sampled from farmers' fields in Ghana ranged from 0.52 to 1.14% and 0.28 to 0.76%, respectively, which are below the critical levels for net mineralization (Janssen, 1993), suggesting the need to improve the quality if maximum benefits are to be derived from their usage by the resource poor farmer. Within most small holder communities, the demand for animal manure is usually greater than its limited supply

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and free grazing poses difficulties in collecting and transporting this important organic resource (Lekasi *et al*., 2003). These difficulties must not preclude the use of animal manure as inputs to soil but rather that they be utilized in more labour efficient and cost effective ways. Since it is believed that any short or long-term change in climate is likely to force farmers to adopt new agricultural practices including choice of crop varieties, timing of major farming operation and designing of alternative production system, it is necessary to enhance the capabilities of farmers respond to changing circumstances in order to reduce vulnerability to food security. This paper aimed at improving the quality of manure through composting with *Chromolaena odorata*, *Stylosanthes guianenesis*, which are commonly found on farmers' field.

MATERIALS AND METHODS

Study site: The study was in 2006 conducted at the Soil Research Institute, Kwadaso-Kumasi, Ghana (6°40' N 1°40' E). The area receives bimodal rainfall of 1200 mm per year with peaks in June and September. The major soils of the area is Ferric Acrisol, pH (water) 5.2, N and p-levels, 0.13 and 1.25 mg kg^{-1}, respectively.

Compost materials: *Chromolaena odorata*, *Stylosanthes guianensis*, maize stover and cattle manure were used for preparing the compost. *Chromolaena odorata*, *Stylosanthes guianensis* and maize stover were selected because they are abundant on farm lands. *Chromolaena odorata* and *Stylosanthes guianensis* are high biomass producing plants classified as high quality organic materials (Quansah *et al*., 2001). Maize stover on the hand is a low quality material that is usually gathered after harvest and burnt (N'dungu *et al*., 2003). Detailed quality characteristics of the compost materials is provided by Quansah *et al*. (2001) and Fening *et al*. (2005).

Compost preparation: Two types of compost were prepared: 1:1 compost comprising 1 part made up of *Chromolaena*, *Stylosanthes*, maize stover mixture and 1 part manure, then 2:1 compost, comprising 2 parts of *Chromolaena*, *Stylosanthes*, maize stover mixture and 1 part manure. The plant materials were chopped to 30-45 cm length to increase their surface area. Fifty kilogramme each of the plant materials and cattle manure on dry weighty basis were mixed together to make the compost. Twelve pits each measuring 2×1 m with a depth of 30 cm were dug. The compost pile was built by putting dry field materials at the bottom of the pit. Water and then wood ash were sprinkled on this layer. This was then followed by 50 kg of the compost mixture. A little top soil was sprinkle on it (Quansah and Yeboah, 2000). The procedure was repeated using the same layer materials. The pile was completed with a cover of a layer of top soil. Lastly the whole pile was covered with banana leaves. The compost pile was replicated three times. Water was occasionally sprinkled on the pile. The pile was turned four times at two weeks intervals. The heap was carefully scooped from one pit to the other close to it. Water was sprinkled at places where the materials were found to be dry. In the 2:1 compost 100 kg each of *Chromolaena*, *Stylosanthes* and maize stover and 50 kg of the manure were used following the same procedure. The materials were composted for 56 days after which samples were analysed for N, P, K, C, Mg and Ca. Total N and P were determined colorimetrically (Parkinson and Allen, 1975) and K by flame photometry (Anderson and Ingram, 1993). The C content was determined using the Nelson and Sommers (1982) wet combustion procedure while Ca and Mg content was estimated using the procedure of Anderson and Ingram (1993).

Mineralization experiment: Decomposition and nutrient release from the composts were determined under laboratory and field conditions using the leaching tube incubation procedure (Stanford and Smith, 1972) and the litter bag technique, respectively. The leaching tube incubation method gives an estimate of potential nutrient release under optimal conditions of moisture and temperature. Glass tubes of 200 mm length with a diameter of 20 mm were used. Ten grams soil sample collected from the experimental site was put into leaching tubes of 2 cm diameter and 20 cm long and 100 mg each of compost were added to the soil in the tube. Each compost type was replicated three times in a completely randomized design. Control treatments (0% compost) were also included in the set up. The experiment was conducted under laboratory conditions with maximum room temperature of about 27°C. The samples in the tubes were leached at 1, 2, 4, 6 and 8 weeks with 100 mL of 1.0 M KCl. Nitrate-N, ammonium-N, phosphorus, calcium and magnesium were determined in the leachate. Total mineral-N (NH_4^+ and NO_3^-) in 10 ml aliquot of the leachate was determined by the Kjeldahl distillation method. Sodium hydroxide (40%) and Devarda's Alloy which reduces NO_3^- to NH_4^+ were used for the distillation followed by the titration of the distillate trapped in boric acid solution with 0.02 M HCl (Keeney and Nelson, 1982). Phosphorus in 5 mL aliquot of the leachate was determined on a spectrophotometer by the blue ammonium molybdate with ascorbic acid as a reducing agent. Calcium and magnesium in the leachate were determined by EDTA titration. A solution of 0.02 M EDTA was titrated with 10.0 mL aliquot of the leachate using cal red and Eriochrome Black T indicators for calcium and magnesium determination. After each leaching event the tubes were subjected to mild suction to bring the water content of each tube to 60-70% water holding capacity.

Litter bags measuring (20×30 cm) were made from nylon mosquito nets (1 mm mesh size). The design of the experiment was a randomized complete block with three replicates. A 100 g each of the compost types were put in the litter bags and buried in a predetermined randomized sequence, 20 cm apart, at a depth of 10 cm in two parallel lines. A safety pin attached to a stainless steel nail anchored each bag to the soil. Each treatment had four samples.

Dry matter disappearance from the decomposition bags was monitored at 1, 2, 4, 6 and 8 weeks (Anderson and Ingram, 1993) after incubation. At each sampling time, the remaining composts from the bags were dried at 65°C to a constant weight and their dry weights recorded. The materials were then ground to less than 1 mm particle size and analyzed for total nitrogen, phosphorus, potassium, calcium, magnesium and organic carbon. The amount of nutrients remaining in the litter bags at each sampling time were determined by multiplying the masses of the nutrients remaining by their respective concentrations as described by Giashuddin *et al.* (1993).

$$\%\text{ nutrient released} = 100 - \%\text{ of the original nutrient content remaining}$$

For each treatment, decomposition rate and nutrient release constants were determined from which time to 50% decomposition and nutrient released were estimated. The decomposition and nutrient release constants, k, were determined by the negative exponential model:

$$m_t/m_o = m_o e^{-kt}$$

Where:

m_t = Mass of material remaining at time t in days

m_o = Initial mass of material or nutrient

Half life (t_{50}) was calculated as:

$$t_{50} = \frac{-\text{In}(0.5)}{k}$$

Data analysis: Laboratory analysis of manure and soil samples were done in duplicates and presented as means of duplicate samples. For the incubation experiment and the litter bag decomposition studies on the field, analysis of variance was performed with GenStat (2002) Software Release 6.1 on the nutrient release/loss data obtained. Where a significant variance ratio was obtained, significance difference was separated using the Least Significant Difference (LSD) method at 5% level of significance. Coefficients of variation among the means were also calculated.

RESULTS

Chemical characteristics of compost: Composting improved the nutrient content of both compost compared to the manure. The N concentration for instance was increased by 53 and 102%, respectively for the 2:1 and 1:1 composts. The resource qualities of the composts were however, different based on the chemical characteristics (Table 1). The 1:1 compost had the highest N, P and K concentrations. The pH declined approximately by 27 and 19%, respectively for 1:1 and 2:1 compost types. Organic carbon concentration was lowered from 46.5 - 34.2% and 46.7 - 32.6% for 1:1 and 2:1 composts respectively. Mineralization of carbon and enrichment of N lowered the C/N ratio of both compost mixtures below 30 as at the end of composting. Aqueous compost extracts had germination indexes of 71.1% and 83.8%, respectively for 1:1 and 2:1 composts.

Mineralization experiment: The 1:1 compost showed net N immobilization of -57 mg kg^{-1} soil during the first and second weeks of incubation while that of the 2:1 compost was -56 and -9 mg kg^{-1} soil over the same period (Fig. 1). This was followed by net N mineralization for both compost types. Ammonium-N was mineralized from both compost types throughout the study period except for the 7th and 14th and the 28th day for the 1:1 and 2:1 compost respectively (Fig. 2). Nitrate-N from both composts were immobilized throughout the incubation period except for 2:1 compost on the 28th and 56th days of composting (Fig. 3). Phosphorus was immobilized in both composts throughout the incubation period except on the 28th and

Table 1: Resource quality analysis of composted cattle manure

Property	1:1 composted manure	2:1 composted manure
pH (1: 5)	6.58 (8.40)	7.23 (8.60)
Total nitrogen N (%)	1.46 (1.90)	1.10 (1.89)
Org. C (%)	34.20 (46.50)	32.58 (46.70)
Total phosphorus (%)	0.31	0.28
Total potassium (%)	1.26	0.68
Total calcium (%)	0.45	0.62
Total magnesium (%)	0.36	0.32
C:N ratio	23.4	29.6
Germination index	71.10	83.80
Colour	Dark brown	Dark brown
Texture	Coarse	Coarse
Smell	Slightly earthy	Slightly earthy

Values represent means of duplicate samples. Initial values for pH, C and N are presented in brackets

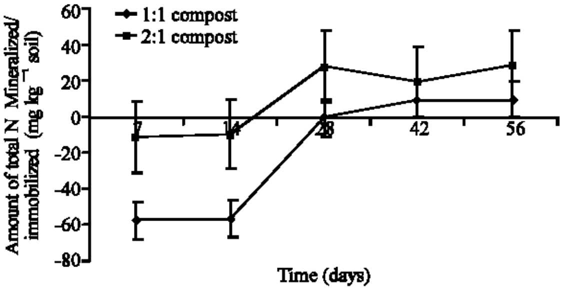

Fig. 1: Net total-N mineralized/immobilized from compost. Bars denote SED at 5%

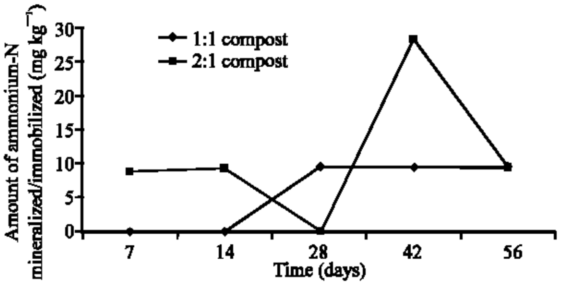

Fig. 2: Net ammonium-N mineralized/immobilized from compost. Bars denote SED at 5%

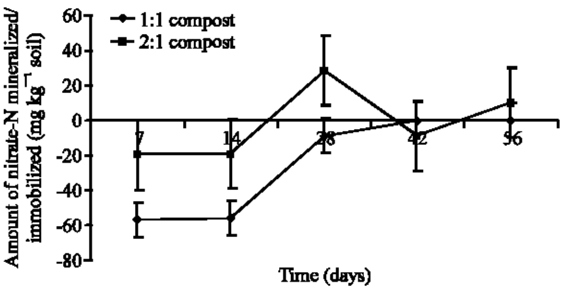

Fig. 3: Nitrate-N mineralized/immobilized from compost. Bars denote SED at 5%

42nd days of composting when net mineralization of less than 1 mg kg^{-1} soil was observed (Fig. 4). Mineralization of calcium in both composts occurred during the first 14 days of incubation followed by immobilization (Fig. 5). Magnesium release patterns for both compost types followed similar trends except on the 28th day of incubation when the 1:1 compost immobilized and the 2:1 compost mineralized (Fig. 6).

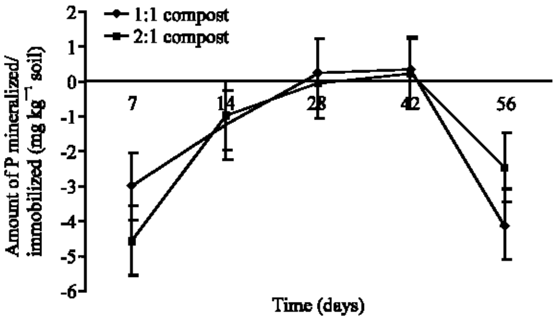

Fig. 4: Net phosphorus mineralized/immobilized from compost. Bars denote SED at 5%

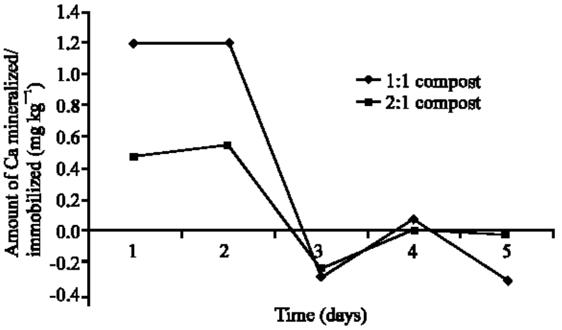

Fig. 5: Net calcium mineralized/immobilized from compost. Bars denote SED at 5%

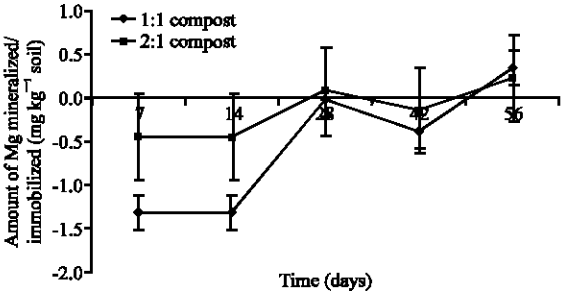

Fig. 6: Net magnesium mineralized/immobilized from compost. Bars denote SED at 5%

Decomposition and nutrient release patterns of compost: The release of N and P were highest at all retrieval periods in the 2:1 compost than in the 1:1 compost except on the 12th and 2nd weeks of incubation respectively (Fig. 7, 8). Both compost types immobilized C during the first two weeks of incubation followed by mineralization up to the end of the incubation period (Fig. 9). The C: N ratio of the 2:1 compost declined up to the 6th week of incubation and then assumed a linear trend up to the 8th week (Fig. 10). The C: N ratio of the 1:1 compost on the other hand, declined from the start of incubation up to the 4th week and rose up by the end of the 6th week of incubation.

Table 2 shows the decomposition rate constants and half-life of the two composts after 56 days of

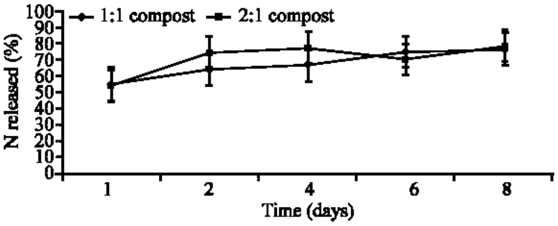

Fig. 7: Nitrogen release patterns of decomposing compost *in situ*. Bars indicate LSD at p = 0.05

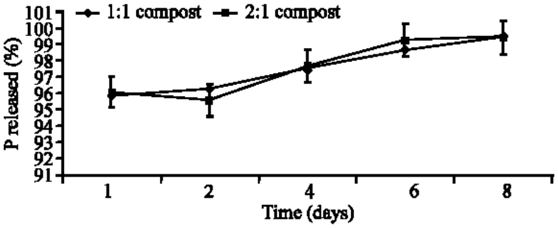

Fig. 8: Phosphorus release patterns of decomposing compost *in situ*. Bars indicate LSD at p = 0.05

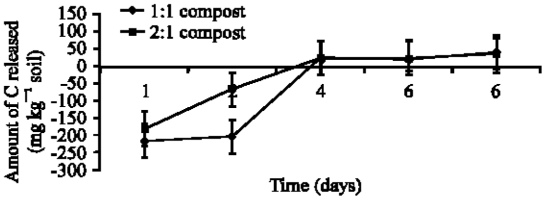

Fig. 9: Carbon release patterns of decomposing compost *in situ*. Bars indicate LSD at p = 0.05

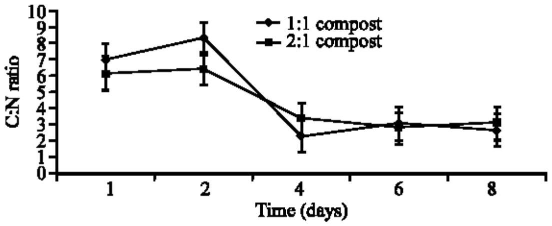

Fig. 10: C: N ratio of decomposing compost in-situ. Bars indicate LSD at p =0.05

Table 2: Decomposition rate constants (k) and half-life (t_{50}) values for two compost types

Parameter	1:1 compost	2:1 compost
k (week^{-1})		
Half-life (observed)	0.085	0.056
	6	7
Half-life (calculated)*	8	12
R^2	0.927	0.836

Values are the means of duplicate samples. $^{*}\text{Half}-\text{life}=\frac{-\text{In}(0.5)}{\text{k}}$

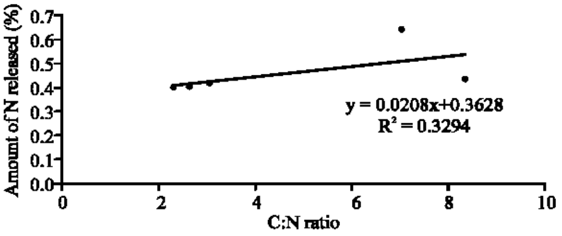

Fig. 11: Relationship between C: N ratio of 1:1 compost and amount of nitrogen released

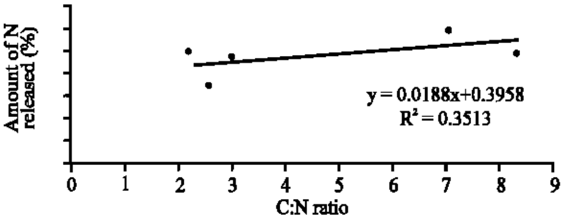

Fig. 12: Relationship between C: N ratio of 2:1 compost and amount of nitrogen released

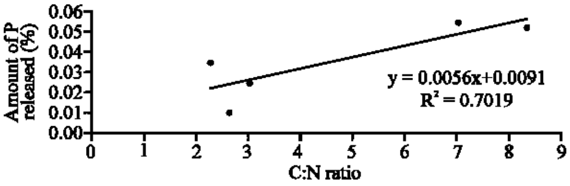

Fig. 13: Relationship between C: N ratio of 1:1 compost and amount of phosphorus released

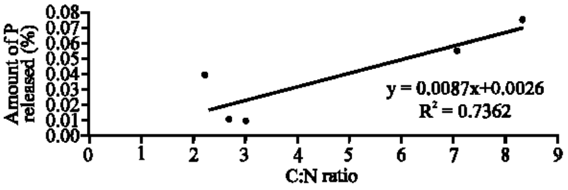

Fig. 14: Relationship between C: N ratio of 2:1 compost and amount of phosphorus released

decomposition. Half-life values of 8 and 12 days were recorded for 1:1 and 2:1 composts respectively. The 1:1 compost had a higher decomposition rate (k = 0.085) than the 2:1 compost (k = 0.056).

Figure 11-14 illustrate the effects of C: N ratio on N and P release of the two compost types. Positive correlations were observed between the C: N ratio and the releases. R^2 values of 0.33 and 0.35 for N and 0.70 and 0.74 for p-value were recorded for 1:1 and 2:1 compost types respectively.

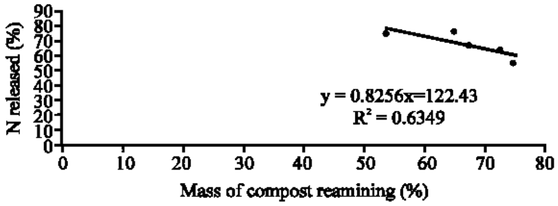

Fig. 15: Relationship between percent mass of 1:1 compost remaining and amount of nitrogen released

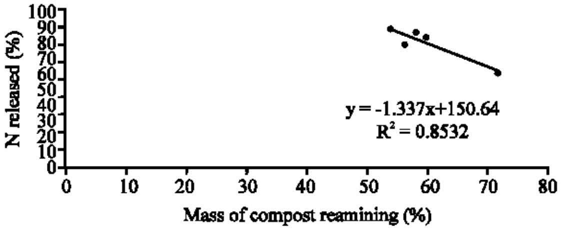

Fig. 16: Relationship between percent mass of 2:1 compost remaining and amount of nitrogen released

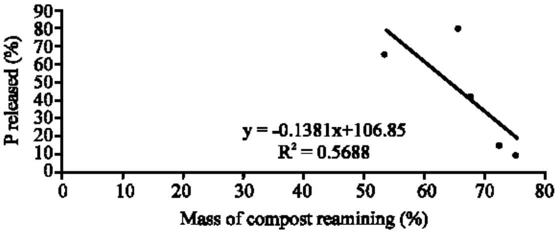

Fig. 17: Relationship between percent mass of 1:1 compost remaining and amount of phosphorus released

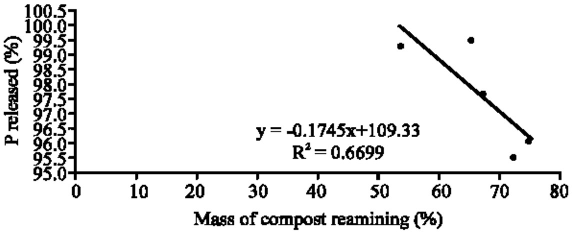

Fig. 18: Relationship between percent mass of 2:1 compost remaining and amount of phosphorus released

Figure 15-18 show the relationships between mass of composts remaining and the amounts of nutrient released. In all cases, negative correlations were observed between the mass of composts remaining and nutrient released. The association between mass of compost remaining and N and P released gave R^2 values of 0.63 and 0.83 and 0.57 and 0.67 for 1:1 and 2:1 compost types, respectively.

DISCUSSION

Composting improved the nutrient content of cattle manure and therefore its fertilizer value. The N concentration for instance was increased by 53 and 102% respectively for the 2:1 and 1:1 composts which, suggests that the composting materials are potentially good organic amendments for improving the fertilizer value of cattle manure. Nitrogen concentration of the finished product (compost) was lower compared to the initial compost mixture for both compost types (1.90-1.46% and 1.89-1.10% for 1:1 and 2:1 composts, respectively). This finding supports the work of Barrington *et al.* (2002), who reported on N losses for compost made of several types of bulking agents or sewage sludge. Factors controlling the magnitude of N losses from compost have been investigated in several studies. Martins and Dewes (1992) measured the different pathways of nitrogen losses and found that they represented 47-77% of the initial total nitrogen content of the compost. Hansen *et al.* (1989) measured nitrogen and dry matter losses of 23 to 32% and 13 to 23%, respectively when composting poultry manure with either sawdust or corn cob at a C/N ratio of 20 or 25. The true merits of composting are thus often queried given the N losses associated with the composting process. It has been reported however, that comparing final to initial concentrations of nutrients can be misleading because of simultaneous dry matter losses (Breitenbeck and Schellinger, 2004; Eghball *et al.*, 1997; Tiquia *et al.*, 2002).

Total carbon concentration declined by 36 and 43% in 1:1 and 2:1 composts types respectively. This may have been due to microbial decomposition of C and release as CO_2 from the composts. Michel *et al.* (2004) also reported 54-79% C losses from straw-amended dairy manure in Ohio. The C: N ratio of both compost types declined as composting progressed and attained final values of 23 and 30 for 1:1 and 2:1 composts respectively. A number of researchers have observed a significant reduction in C: N ratios when different sources of organic materials have been composted. For example, Thambirajah *et al.* (1995) and Baharuddin *et al.* (2009) observed a substantial reduction in C:N ratio when they composted empty fruit bunches (with a relatively high lignin content) with manure.

The pH for both compost types dropped from 8.40 to 6.58 and 8.60 to 7.23 for 1:1 and 2:1 composts, respectively. This observation might be due to ammonification and mineralization of organic matter by the activities of microorganisms. In contrast, Gaind and Gaur (2003) showed an increase in pH value during the first seven days due to ammonification followed by a gradual decrease to a final pH ranging between 6.5 and 6.9. A high pH is generally a sign of immature compost. Nzuma *et al.* (1998), reported that N contents in manure could be related to the pH of the manure during the composting process. In heaps where conditions are aerobic, the compost pH is normally high (8.0-9.0). This tends to stimulate N losses via volatilization. On the other hand, compost stored under anaerobic conditions tends to produce organic acids that lead to lower pH (<7) and therefore minor losses via volatilization (Kihanda and Gichuru, 1999). Al-Kanani *et al.* (1992) also reported a well established link between N loss via ammonia volatilization and pH, with volatilization decreasing as pH decreased. Thus an alkaline pH favours the formation of NH_3 from NH_4^+ which might result in NH_3 volatilization. The near neutral pH of the compost is advantageous since it can buffer the soil against extreme pH.

The effective action of different microorganisms on the decomposition of the composts resulted in the overall reduction in the size of the composting material to give a deep brown chocolate compost colour. Germination indexes for both compost types were greater than 70% (i.e., 71.10 and 83.80% for 1:1 and 2:1 compost types respectively). Germination index values greater than 50% indicates a phytotoxin-free compost (Zucconi *et al.*, 1981). Based on the germination index, it appears that both compost types had reached maturity by the 90th day of composting. Compost maturity is very important because immature composts still exhibit microbial activities when applied to the soil which might cause microorganisms to compete with the plants for available soil nitrogen (nitrogen block). Immature compost may also contain high levels of organic acids which can damage plant growth when used as soil amendment.

A partial N immobilization was observed in both compost types during the first 14 days of incubation in the laboratory (Fig. 4). This finding is similar to the results of Mugwira and Mukurumbira (1984) which showed a depression in plant growth in the first two weeks in manured pots. Castellanos and Prat (1981) also observed immobilization of N in soils treated with aerobically composted dairy cattle and beef feedlot manures. Much longer periods of immobilization from cattle manure of up to 105 days have been observed (Fauci and Dick, 1994). On the contrary, Delve *et al.* (2001) observed that all manure types released N in the first week of incubation but immobilized N for 17 to 28 weeks, resulting in a lack of response in *Zea mays* (L.) growth to any of the manures in both pot and field experiments.

Some flushes of net mineral N were observed from the 4th week up to the end of the laboratory incubation study (Fig. 4), similar to that reported by Nhamo *et al.* (2004). Under field conditions, these flushes occur after the initial wetting of the soil by rains and provide N to young plants early in the season. It is the balance between this initial mineralization and leaching losses together with crop uptake that determines the initial benefits of manures or composts to crops. Mineralization of ammonium-N through out the incubation period is another interesting observation of importance to plant growth. Because it is not only the total amount of mineral N available that is important to the plant, but also the proportion of ammonium-N. Plant uptake of other cations, such as calcium, magnesium and potassium, may be reduced when ammonia dominates (Bunt, 1988).

Unlike the laboratory observations, no immobilization of N was observed during field incubation of the two compost types (Fig. 10). This phase of mineralization was not expected because it was calculated that N immobilization would occur if the C: N ratio of the compost exceeds 15 to 20 (Castellanos and Pratt, 1981; Van Faassen and Van, 1987). Nogales *et al.* (1982) also reported that in general, mineralization process is enhanced when the organic products that are added to the soil has an adequate C:N ratio less than 20. Several other authors (Myers *et al.*, 1994; Cadisch *et al.*, 1993) have reported an initial immobilization of mineral N in the decomposition of organic materials with C:N > 25. The C: N ratio for both compost types were however greater than 20. These findings may suggest that under the field conditions, both compost types had sufficient N to meet microbial demands from the initial phase of mineralization. Furthermore, some soil properties such as the C:N ratio may also have had an effect on the N mineralization patterns observed from the start to the end of the incubation study. On the average, the C: N ratio of the soil in which this study took place was 14.7. Agbenin and Goladi (1998) reported that C: N ratio of soils higher than 10 is a critical ratio for net N mineralization to occur in soils.

C: N ratio of the composts during the field incubation study declined sharply from the 2nd to the 4th week for both compost types (Fig. 13). This decline suggested that the available carbon for microbial breakdown was being rapidly used up during this period of decomposition and supports the findings of Kanchikerimath and Singh (2001) and Baharuddin *et al.* (2009) that attributed decreasing C: N ratio to an increase in labile fraction of organic matter. Correlation analysis between C: N ratio and N release under field conditions indicated R^2 values of less than 0.40 in both compost types (Fig. 14, 15). This study has therefore shown that C: N ratio on its own cannot be used to explain the mineralization and immobilization patterns of decomposing organic materials and agrees with the findings of Heinrich (2009). Tetteh (2004) found that the most probable factor is the microbial biomass because in situations where microbial populations are high, the introduction of organic materials into the soil will result in microbes taking up nutrients especially N, P and C for energy, multiplication and other microbiological functions.

The results obtained from the laboratory incubation study have shown that phosphorus immobilization would occur if any of the compost types were to be applied to the soil (Fig. 7). Hue and Sobieszczyk (1999) explained that following mineralization, phosphorus is quickly adsorbed onto the surface of positively charged particles; its availability in solution is therefore typically low even when the total content is high. Furthermore, microbes might have probably taken up the released phosphorus. Jimenez *et al.* (1993) also reported low mineralization rates of P immediately after application in a municipal waste compost, but after a residence time of three months, provided sufficient P for plant growth. Although correlation between the C:N ratio and N release showed R^2 values of less than 0.40, that of phosphorus was relatively highly correlated with R^2 values greater than 0.70 for both composts (Fig. 16, 17). However, unlike N, much needs to be known about how the C: N ratio of the composts affect P availability for effective management of nutrient release and P synchrony.

CONCLUSION

The study demonstrates that the fertilizer value of cattle manure as a soil amendment can be improve through composting with *Stylosanthes guianensis*, *Chromolaena odorata* and maize stover. The study also indicated the time of application of the composted manure such that nutrient release and maximum nutrient uptake can be synchronized. There might be limitations as to the quantities of biomass of *Stylosanthes guianensis* and *Chromolaena odorata* a farmer may obtain from his field. Studies using other materials will need to be evaluated, meanwhile farmers can combine compost more effectively with strategic quantities and placement of mineral fertilizers and so more precisely meet the nutritional needs of crops.

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