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Efficacy of Selected Crop Residues and Rock Phosphate in Improving the Quality of Cattle Manure

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ABSTRACT
Cattle manure (CM) is noted for its poor nutrient quality especially in Ghana where most cattle are fed on a free range. There is therefore a need to improve its quality since it is a vital nutrient resource for smallholder farmers. An experiment was thus carried out by composting cocoa pod husk (CPH), palm kernel cake (PKC) and rock phosphate (RP) to investigate their effectiveness for use as nutrient sources for improving the fertilizer value of cattle manure (CM). Four compost ratios (CM + PKC (3:1), CM + CPH (3:1), CM + RP (3:1) and CM + PKC + CPH + RP (3:1:1:1)) were formulated and replicated three times in Randomized Complete Block Design (RCBD). The findings showed that, addition of CPH, PKC and RP to CM improved the fertilizer value of cattle manure. The CM + PKC + CPH + RP (3:1:1:1) compost increased the nitrogen (N), phosphorus (P) and potassium (K) contents of cattle manure by 73%, 145% and 50%, respectively and was therefore considered the most effective in enhancing the nutrient value of cattle manure. This compost was thus evaluated through field application to maize. The study also revealed that increasing the application rate of compost increased maize grain yields. Hence, cocoa pod husk, palm kernel cake and rock phosphate can be exploited for use as important resources for improving the fertilizer value of cattle manure.

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Cattle manure; cocoa pod husk; enriched compost; fertilizer value; palm kernel cake

Introduction

Ghana, like many other countries in Africa, has been facing an escalating soil fertility crisis over decades with predicted losses of 35, 4 and 20 kg ha^{-1}, respectively, for N, P and K annually (Jayne et al. 2015). This has often occurred through drivers such as nutrient mining by crops, leaching of soil nutrients and inappropriate management practices resulting from lack of fallow periods, land degradation and deforestation (Morris et al. 2007). In view of this, Morris et al. (2007) suggested that intensive farming cannot be sustained unless mineral or organic or both nutrient sources are applied to the soil to replace those lost through intensive farming activities.

The use of organic fertilizers in the form of agricultural residues, manures and composts for soil fertility improvement is paramount (Omotayo and Chukwuka 2009). The commonly used organic manures in Ghana are cattle and poultry manures. Out of these two manures, cattle manure has a relatively low nutrient content (1.20% N, 0.07% P, 0.09% K, 0.25% Ca, and 0.08% Mg) as compared to poultry manure (2.20% N, 0.77% P, 0.91% K, 1.70% Ca and 0.42% Mg) (FAO 2005). The poor quality of cattle manure, for example, significantly impedes its adoption for application (Vanlauwe and Giller 2006) resulting in high quantities needed for application. These problems

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associated with its use call for research aimed at optimizing cattle manure to enhance its quality. Most studies have attempted improving the N content of manure using crop residues (Ewusi-Mensah 2009; Kolade et al. 2006) and P using agro-minerals (Mahimairaja, Bolan, and Hedley 1995) by composting. However, such studies did not simultaneously address other major macronutrients which are essential for plant growth.

Agricultural wastes are readily available in Ghana. Common agricultural wastes which have the potential of being used as sources of organic fertilizer include: cocoa pod husk (CPH), palm kernel cake (PKC), cattle manure (CM), poultry manure (PM), among many others. Cocoa pod husk contains approximately 1.47% N, 0.19% P and 3.35% K (Adamtey 2005) and thus, can serve as a rich source of potassium. Similarly, the burning of PKC in agro-processing industries has become an environmental problem that can be resolved by composting and application to the soil as a rich source of nitrogen (2.88%) (Kolade et al. 2006). Rock phosphate has a relatively high P content (28–30%). However, it cannot be used directly as a fertilizer due to its slow P release for plant use (Basak 2017; Reddy, Kumar, and Khosla 2002). The rationale behind the use of RP is that research has proven that composting animal manure and crop residues with RP enhances the dissolution of RP (Singh and Amberger 1991). It is therefore widely practiced as a low-input technology to improve the fertilizer value of organic manure (Mahimairaja, Bolan, and Hedley 1995). Compost enrichment with RP is important because out of the over 70% of the global RP deposits found in Africa, paradoxically, a woeful 2.8% of the total 28.5% of the total global phosphate rock production is utilized in Africa (Satoshi et al. 2014), making it over-abundant yet under-exploited and underutilized. Cattle manure also contains approximately 0.52–1.40% N and 0.28–0.76% P (Fening et al. 2005). Different agricultural wastes have varying concentrations of nutrients and thus, will supply relatively different quantities of nutrients following mineralization. Their mineral composition gives an indication of their potential for use as a soil amendment. Therefore, the use of agricultural wastes will be of immense benefit to farmers, as it is a sustainable and environmentally friendly way of restoring and improving soil fertility and productivity (Agbeniyi, Oluyole, and Ogunlade 2011). Composting agricultural wastes as a means of improving soil fertility and boosting soil carbon sequestration (Ganunga, Yerokun, and Kumwenda 1998) acts as a long-term reserve and a slow-release source of soil nutrients (N, P, K) (Sullivan et al. 2002). It is therefore envisaged in this study that when agricultural wastes are fully exploited, they could bridge the food security gap.

Based on the hypothesis that, composting cattle manure with rock phosphate, cocoa pod husk and palm kernel cake can increase fertilizer value of manure, this current study was carried out to a**ssess** the effectiveness of using rock phosphate, cocoa pod husk and palm kernel cake in improving the fertilizer value of cattle manure.

Materials and methods

Experimental site

This study was conducted at the experimental farm of the Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi-Ghana. The experimental site lies within latitude 06°68.290′ N and longitude 001°55.158′ W at 287 m elevation a.m.s.l. in the Semi-deciduous forest agro-ecological zone of Ghana.

Compost preparation

Resource materials

The resource materials used in the compost preparation were cattle manure (CM), cocoa pod husk (CPH), palm kernel cake (PKC) and rock phosphate (RP). Togo rock phosphate (30% P_2O_5) was used in the compost preparation.

Composting procedure

Twelve designed waterproof tarpaulin sheets measuring 1.30 m x 0.90 m were divided into two using a sharp knife. These were then re-sewed together using a 15 cm wide mesh nets separating the sheets to enhance aeration.

The experimental site was then cleared and demarcated for composting. The resource materials used for the compost were air-dried and weighed. Before mixing them in the various ratios, the CPH was cut into smaller pieces to increase the surface area and consequently enhance faster decomposition by microorganisms. The different resource combinations and their respective ratios (w/w) were: CM + PKC, 3:1; CM + CPH, 3:1; CM + RP, 3:1 and CM + PKC + CPH + RP, 3:1:1:1. The different ratios, each totaling 60 kg of dry matter were mixed with a spade after which water was sprinkled to obtain 70% moisture content. Each mixture of resource materials was then heaped on the ground. The compost heaps were covered with thick black polythene sheets to protect it from excessive rains and sunshine as well as nutrient loss during the composting process which was carried out in the open (aerated composting). The compost combinations which constituted the treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated three times each.

Management practices

Based on the basic principle by Dalzell et al. (1987) that two or three times turning of heaps in simple composting systems using natural air flow is adequate, the composts were turned after two weeks and seven weeks of heaping, to homogenize the composting materials and the heaps, break up clumps, expose fresh surfaces to microbial attack, facilitate aeration and reduce overheating so as not to kill the beneficial microbes facilitating decomposition in heaps. Moisture content of the compost heaps was adjusted anytime turning was done. Temperature (using a mercury-in-glass thermometer) and pH (1:1 sample: distilled water ratio by Motsara and Roy (2008) of the compost treatments were monitored weekly throughout the 90-day composting period. The indices used for assessing compost maturity in this study were; near-neutral pH, compost temperature close to the environmental temperature, a dark brown with a slightly earthy smell and C/N ratio between 10:1 and 15:1 (Bationo 2008).

Evaluating CM + PKC + RP + CPH (3:1:1:1) compost effect on grain yield of maize

To evaluate efficacy of the best compost type (CM + PKC + RP + CPH (3:1:1:1)) to crop yield improvement, a three-year field experiment was carried out. The field experiment was arranged in Randomized Complete Block Design (RCBD) with three replications for each treatment. Five levels of compost (0%, 25%, 50%, 75% and 100% of 5 Mg/ha) were randomly allotted to each plot. The treatments were designed and formulated based on the compost recommendation rate of 5 Mg/ha by Ministry of Food and Agriculture (2005). Farmers' preferred maize variety in the study area, Omankwa (90–95 days' maturity) was used as the test crop. At physiological maturity, maize plants were harvested for determination of grain yield and adjusted to a moisture content of 15%.

Laboratory procedures

Representative samples of the organic materials (CM, CPH and PKC) were analyzed prior to composting for their selected physico-chemical properties. Samples for laboratory analysis were prepared by air drying for five days followed by oven-drying at 70°C for 72 hours, milling them with the aid of Perten's laboratory mill 3310® (Finland), and passing them through a 2 mm mesh sieve. The parameters determined prior to and after composting were organic carbon (C), total N, total P, total K, dry matter content, polyphenol, lignin and C: N ratio. Organic carbon was determined using the Modified Walkley-Black method (Motsara and Roy 2008), total N; modified Kjeldahl method (Motsara and Roy 2008), total P (Bray-P1 method) and total K (flame photometer) (Motsara and Roy

2008). Lignin and polyphenol contents were also determined using the acid detergent fiber method and Folin-Denis method, respectively, by Anderson and Ingram (1998).

Statistical analysis

All data collected during the experiment were subjected to One-way Analysis of Variance (ANOVA) with randomized blocks procedure using GenStat (2009) software. Results were then presented as means for each treatment while Fischer's protected Least Significance Difference (LSD) method was used for means separation at $p \leq 0.05$.

Results

Selected chemical characteristics of resources used

The chemical characteristics of the organic resources used for the compost are reported in Table 1. The CPH had the highest total OC content (45.4%), while CM had the least (31.2%). The total N contents of CM, CPH and PKC were 1.5 ± 0.2, 1.7 ± 0.4, and 2.5 ± 1.1, respectively. The highest C: N ratio of 29.2 was recorded in CPH. Cocoa pod husk contained the highest dry matter content, whereas CM had the least N content.

Variations in pH during the composting process

Figure 1 represents the average weekly pH of the different compost heaps. The pH of treatments CM + PKC, CM + CPH, CM + RP, CM + PKC + CPH + RP at 1 week after composting (WAC) were 8.2, 8.9, 8.8 and 8.4, respectively. The pH of the compost heaps remained above 7 throughout the period of co-composting. It was therefore not surprising that, the pH at the end of composting (11 WAC) were 7.6, 8.2, 7.8 and 7.8 for CM + PKC, CM + CPH, CM + RP and CM + PKC + CPH + RP, respectively. Statistically, significant ($p \leq 0.05$) differences were observed among the different treatments from 1WAC to 8WAC, after which no significant ($p \geq 0.05$) differences were observed at 11WAC. Treatment CM + CPH consistently produced the highest alkaline pH throughout the composting process. At 1WAC, pH values in the different heaps were low but increased from 2WAC where pH attained a peak range of 8.5–9.2 (Figure 1). At 3WAC, however, there was a gradual reduction in pH up to 5WAC and a steady increase at 6WAC. There was then a reduction in pH at 7WAC followed by slight insignificant fluctuations up to 11WAC. The pH among the treatments generally reduced from an initial pH range of 8.2–8.9 to 7.6–8.2.

Table 1. Selected chemical characteristics of resources used in composting.

	CM	CPH	PKC
Parameter		Mean ± SD	
Organic C (%)	31.2 ± 12.9	45.4 ± 4.2	43.2 ± 14.8
Total N (%)	1.5 ± 0.2	1.7 ± 0.4	2.5 ± 1.1
Total P (%)	1.1 ± 0.8	1.0 ± 0.9	1.4 ± 1.6
Total K (%)	0.4 ± 0.1	0.3 ± 0.3	2.0 ± 1.6
Lignin (%)	12 ± 12.7	20.5 ± 3.5	8.5 ± 2.1
Polyphenol (%)	0.4 ± 0.2	0.5 ± 0.0	0.3 ± 0.0
Dry matter (%)	85.3 ± 12.4	91.0 ± 4.8	87.1 ± 7.2
C: N	20.9 ± 6.4	29.2 ± 11.3	22.4 ± 16.6

Values are means for three replicates; *Rock phosphate contains 30% P_2O_5 (13.2% P)
CPH: cocoa pod husk, CM: cattle manure, PKC: palm kernel cake, SD: standard deviation.

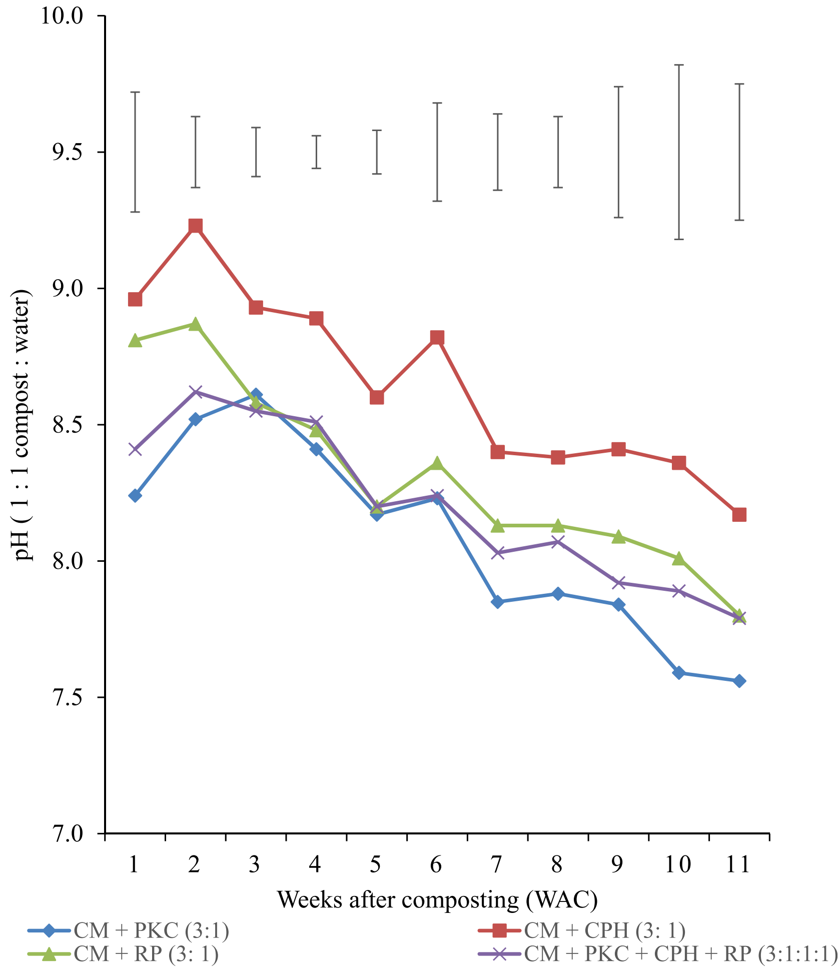

Figure 1. Variations in pH of resource materials during composting. Data points are means of three replicates. (Vertical bars represent LSD at 5%).

Temperature variation during the composting process

Results of the temperature variation during the composting process are presented in Figure 2. Generally, the temperature among the four compost types was similar ($p > .05$) throughout the composting period, except for 3WAC where significant differences ($p = .028$) were observed. The temperature in the compost heaps ranged from 31°C to 33°C at 1WAC, decreased at 2WAC (20°C to 31°C), and increased sharply to a peak of 30°C to 34°C at 3WAC. The temperature then declined (28.6° C to 29.5°C) at 6WAC, increased again (29.8°C to 30.1°C) at 7WAC, where it steadily decreased to a stable temperature of 27°C to 28°C at 11WAC.

The highest temperature recorded during the composting period was 34°C at 3WAC in CM + PKC (3:1) treatment combination. Surprisingly, the least temperature of 27°C was also recorded in the aforementioned treatment at 11WAC. The temperature which prevailed in the four compost heaps was higher than the minimum (22°C to 24°C) and generally lower than the maximum (30°C to 35°C) ambient temperature range recorded during the composting period. The only exception was at 3WAC where CM + PKC (3:1) produced a temperature slightly higher (34.3°C) than the maximum ambient temperature (34°C).

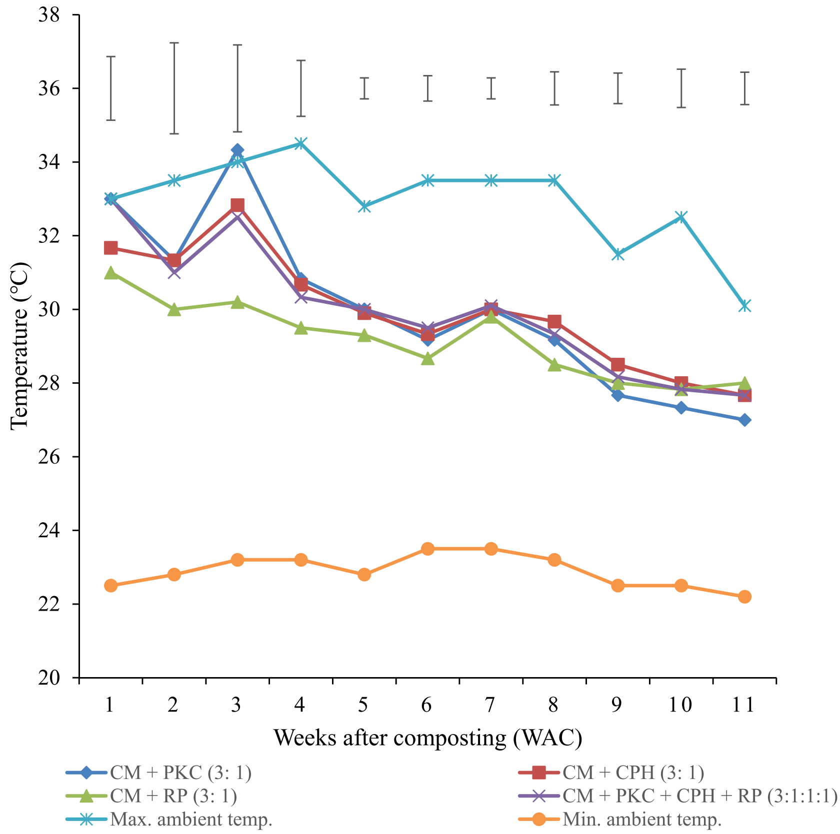

Figure 2. Variations in temperature during the composting process. (Vertical bars represent LSD at 5%).

Table 2. Contribution of cocoa pod husk, palm kernel cake and rock phosphate to the nutrient content of cattle manure.

	Nutrient concentration		
	Total N	Total P	Total K
Resource material	…………………… % ……………………		
CM + RP (3:1)	1.2	2.8	0.5
CM + PKC (3:1)	2.0	0.5	0.5
CM + CPH (3:1)	1.6	0.3	0.6
CM + PKC + CPH + RP (3:1:1:1)	2.6	2.7	0.6
Fpr.	< 0.001	< 0.001	0.240
LSD (0.05)	0.21	0.14	0.20
CV (%)	5.6	4.4	17.9

CPH: cocoa pod husk, CM: cattle manure, PKC: palm kernel cake, RP: rock phosphate, CV: coefficient of variation, LSD: least significant difference.

Potential of the resources used in enhancing the fertilizer value of cattle manure

Table 2 shows that the addition of the different resources (CPH, PKC and RP) to cattle manure (CM) increased its nutrient content after composting. The additives significantly ($p < .001$) increased the total N and P of the four compost types with CM + PKC + CPH + RP producing a significantly higher N followed by CM + PKC. The addition of RP to CM through composting relatively increased the P content of cattle manure by 155%. The addition of PKC to CM also

Table 3. Effect of compost application on grain yield of maize.

	2015	2016	2017
Compost (% RR)		Grain yield (Mg/ha)	
0	1.19	2.23	2.67
25	1.35	2.99	2.77
50	1.50	3.35	3.98
75	1.76	4.85	3.96
100	1.56	4.15	4.76
Mean	1.47	3.51	3.63
Fpr.	0.172	< 0.001	< 0.001
LSD (0.05)	0.49	0.52	0.42
CV (%)	17.5	7.8	6.1

Values are means of three replicates. $\%_{RR}$ Co: percentage recommended rate of compost where 0% = 0 Mg/ha, 25% = 1.25 Mg/ha, 50% = 2.5 Mg/ha, 75% = 3.75 Mg/ha and 100% = 5 Mg/ha; LSD: least significant difference; CV: coefficient of variation.

resulted in relatively increasing the N and K contents of CM by 33% and 25%, respectively. Furthermore, cattle manure plus CPH combination also increased the K content of the CM by 50%. Composting cattle manure with CPH, PKC and RP caused a greater increase in the fertilizer value of cattle manure. Generally, the addition of PKC, RP and CPH to cattle manure and composting resulted in simultaneously increasing the N, P and K contents of cattle manure by 73%, 145% and 50%, respectively.

Effects of compost application on grain yield of maize

The effect of compost application on grain yield of maize is presented in Table 3. It was observed that the application of compost significantly ($p \leq 0.001$) increased grain yield of maize throughout the three-year experimental period (Table 3). On average, maize grain yields of 1.48, 3.51 and 3.63 Mg/ha were observed in 2015, 2016 and 2017 major cropping seasons, respectively. The application of 75% compost (3.75 Mg/ha) produced the highest average grain yields of 1.76 Mg/ha and 4.85 Mg/ha in 2015 and 2016, respectively with relative average grain yield increases of 48% and 118% over the control, respectively. However, in 2017, the highest grain yield of 4.76 Mg/ha was recorded under 100% compost (5 Mg/ha).

Discussion

Chemical characteristics of the selected resource materials

The quality of agricultural resource materials is largely determined by their chemical characteristics. The total N, P and dry matter content of CPH determined were greater than those stated by Adamtey (2005) that CPH contained 1.47% N, 0.19% P and 3.35% K for CPH. Also, with PKC, the total K content was greater (2.0%) than the 0.06% value reported by Adamtey (2005) and Kolade et al. (2006). With the low percentage of total N recorded in CM and CPH, it is probable that when they are applied to the soil directly without composting, there would be immobilization of soil nutrients. Hence, the need for fortification. It was also observed that, among the other organic resources, PKC had the highest total N and K (Table 1). Similar observation was made by Roy et al. (2006) who reported greater nutrient content in processed residues like oilcakes than conventional crop residues. The C: N ratio of CPH (29.2:1) and CM (20.9:1) and PKC (22.4:1) was above the critical value of 20–25 and hence their application will immobilize soil N (Burgess, Mehuys, and Madramootoo 2002). The greater C: N of CPH was due to its relatively low N and higher C content relative to PKC and CM. Each of the organic resource materials is unique with respect to their chemical characteristics. Since applying them individually to the soil may result in immobilization of soil nutrients due to poor quality, there was the need to exploit the nutrients in them by composting with cattle manure and quantify the contribution of each additive to the fertilizer value of cattle manure. Since crop residues are noted to supply sufficient amount of nutrients to the soil, composting is thus, believed to convert the insoluble nutrients into more bioavailable forms by the action of organic acids produced during the composting process (Basak 2017).

Variations in pH during the composting process

Most soils in the high rainfall zones of Ghana are characterized by acidic pH due to the leaching out of basic cations necessary for plant growth. Soil pH is thus, a determining factor for plant nutrient availability (Rahman and Ranamukhaarachchi 2003). In order to increase the availability of soil nutrients, there is the need to apply resources that would buffer the pH of the soil, whiles serving as a soil-fertilizing agent.

There were intermittent increases in pH of the different composts during the period of composting. This may be attributed to the volatile acid reduction and its subsequent reaction with ammonium gas upon protein denaturation (Ramaswamy et al. 2010). The pH at the end of composting of CM + PKC, CM + CPH, CM + RP and CM + PKC + CPH + RP were 7.6, 8.2, 7.8 and 7.8, respectively. Bationo (2008) reported that, while the composting process' natural buffering capacity enables it to accept materials with a broad pH range, Rynk et al. (1992) reported that the preferred range for compost should be between 6.5 and 8.0, and the pH of matured compost should be near neutral (Bationo 2008). Therefore, the pH of the composts at the end of the period indicated that they were matured for use. Thus, CM + PKC, CM + CPH, CM + RP and CM + PKC + CPH + RP have the potential of being used as compost, and consequently as a soil-fertilizing agent.

Variations in temperature during the composting process

Temperature is a key factor that influences the composting process. Monitoring compost temperature therefore aids in examining the progress of composting (Boulter-Bitzer, Trevors, and Boland 2006) and also controls microbial activity during each stage of the composting process. Heat was generated throughout the composting process, however the observed temperature varied though statistically insignificant ($p \geq 0.05$) depending on the type of resource materials used in the compost preparation (Figure 2). Generally, throughout the composting period, heat generated in the composts was in the order CM + PKC > CM + CPH > CM + PKC + CPH + RP > CM + RP. From the results obtained, there is a possibility of the different compost heaps being dominated by bacteria since only mesophilic temperature phase (25°C–40°C) was observed throughout the composting process (Bernal, Alburquerque, and Moral 2009). The inability of the different compost heaps to reach the thermophilic phase could be attributed to heat dissipation due to the smaller volumes of the compost heaps (60 kg) (Themelis and Kim 2002). The volume of substrates used in the compost heaps is a determining factor of heat retained in the compost heaps. The greater the compost volume, the greater the amount of heat retained by the heaps, the more self-insulating it becomes (Richard 2005). The 60 kg volume of the compost heaps therefore exposed the compost to greater heat loss.

Rate of compost turning also serves as a temperature-regulating mechanism in compost heaps. Compost heaps were turned at 2WAC and 5WAC and the moisture content was also adjusted leading to heat loss, hence the low temperatures. This is similar to an observation by Beffa (2002) that air movement in compost resulting from heap turning leads to heat loss as evaporation of moisture occurs in the compost.

Contribution of the resource materials to improving the fertilizer value of cattle manure

The addition of rock phosphate, cocoa pod husk and palm kernel cake to cattle manure increased the fertilizer value of cattle manure after the composting process (Table 2). This confirms an assertion by Roy et al. (2006) that composting can improve the value of crop residues as sources of nutrients. Basak

Table 4. MANOVA for grain yield of maize in response to compost application.

Term	d.f.	Wilk's lambda	Rao F.	n.d.f.	d.d.f.	F. prob.
Year	2	0.0365	369.45	2	28	0.000
Compost	4	0.1041	60.22	4	28	0.000
Year x Compost	8	0.1727	16.76	8	28	0.000

MANOVA: Multivariate Analysis of Variance, n.d.f.: number of degrees of freedom in the model, d.d.f.: number of degrees of freedom with the model errors.

(2017) recorded notable total P increases in rock phosphate-enriched composts. Kolade et al. (2006) and Fening, Ewusi-Mensah, and Safo (2010) also recorded the use of crop residues to increase the fertilizer value of goat manure, poultry manure and cattle manure. However, the nutrient increase observed in this study is greater than the ones observed by earlier researchers. Earlier studies only increased the N content of the manures in question. However, the CM + PKC + CPH + RP (3:1:1:1) compost produced in this study increased the N, P and K content of cattle manure. Kolade et al. (2006) increased the N content of poultry manure (PM) by 24% by composting with palm kernel cake (PKC) in a PKC + PM compost (3:1). Similarly, the N content of goat manure (GM) was increased by 28% by composting with palm kernel cake in PKC + GM compost (3:1) (Kolade et al. 2006). Unlike Fening, Ewusi-Mensah, and Safo (2010) who registered a rise in the N content of cattle manure compost by 53%, the addition of PKC, CPH and RP to CM by composting in this study increased the N, P and K contents of CM by approximately 73%, 145% and 50%, respectively. Considering the problem of soil acidity in most sub-Saharan African countries, the high P content in the compost as a result of the rock phosphate addition is vital. Rock phosphate enhances liming of soils due to its chemical reactivity (Basak and Biswas 2016) through the production of organic acids such as acetic, citric, fumaric, gluconic, oxalic and succinic acids. This improves the soil and increases crop yields (Rashid et al. 2004).

Effects of compost application on grain yield of maize

According to Essel et al. (2020), low inherent fertility of smallholder farms limits maize grain yield. Increasing the application rate of compost resulted in increased grain yields due to the supply of more nutrients (Fashina, Olatunji, and Alasiri 2002) to the maize crop. Significantly, 89.6% (Wilk's lambda = 0.1041, $p = .000$) of the variation in maize grain yields across the three-year experimentation could be attributed to the different compost application rates (Table 4). The general increase in grain yield after the first year of cropping in 2015 corroborates the findings by Kombiok et al. (2016) who observed general increases in grain yield of maize after the first year of cropping with percentage grain yield increase of 57% under plots organically amended in 2009 as compared to 2008, indicating the positive benefits of the residual effects of the treatments applied.

Conclusion

In order for any organic resource material to satisfy conditions as a soil-fertilizing agent, it must have adequate nutrient concentrations and a low C: N ratio to enhance mineralization rate and possible nutrient release to support plant growth. At the end of the study, it was observed that, addition of cocoa pod husk (CPH), palm kernel cake (PKC) and rock phosphate (RP) to cattle manure (CM) and composting improved the fertilizer value of cattle manure. The addition of PKC to CM increased the nitrogen content of cattle manure. Rock phosphate and CPH contributed to an increase in the phosphorus and potassium contents of the cattle manure, respectively. The CM + PKC + CPH + RP (3:1:1:1) compost resulted in the best combination, confirming the null hypothesis that, composting cattle manure with rock phosphate, cocoa pod husk and palm kernel cake increases the fertilizer value of manure. The CM + PKC + CPH + RP (3:1:1:1) compost increased the N, P and K contents of cattle manure by 73%, 145% and 50%, respectively. This implies that rock phosphate, cocoa pod husk and palm kernel cake can potentially be exploited for use as nutrient amendments for improving the nutrient contents of cattle manure and for subsequent soil fertility improvement. The application of 5 Mg/ha CM + PKC + CPH + RP (3:1:1:1) compost is thus, recommended for increased maize production and soil fertility improvement in the study area.

Disclosure statement

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