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FERTILIZER VALUES OF COMPOSTS AS AFFECTED BY PLANT MATERIALS AND COMPOSTING DURATION ON MAIZE (*Zea mays*) PERFORMANCE

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ABSTRACT

Chemical properties and nutrient release pattern from compost are influenced by composted plant materials (CPM) and duration of composting (DC). The following plant materials; guinea grass (GGC), tridax weed (TWC), siam weed (SWC) and maize stover (MSC) were composted with cow dung. Pot and field experiments were carried out to evaluate the effect of these CPM on growth yield performance of maize, and the properties of soil after harvest. The pot trial was a 4 × 5 factorial experiment laid out in a completely randomized design (CRD) with three replicates while the field experiment was a 4 × 3 factorial arranged in a randomized complete block design (RCBD), replicated three times. Data collected on initial and soil properties after harvest, growth, dry matter yield (DMY), nutrient uptake and yield of maize were subjected to analysis of variance and means separated using Duncan Multiple Range Test. Results showed that MSC compost had the highest N content while GGC had the highest K. Phosphorus (P) content was similar for all the CPMs. Results of pot experiment showed that maize growth was higher ($p \leq 0.05$) with GGC, TWC and MSC of 3, 4 and 5 months DC. The DMY and P-uptake increased with increasing DC. On field trial, plants height was similar for all the CPM that received MSC and GGC gave similar highest DMY which were significantly higher than TWC and SWC. MSC gave the highest N-uptake while GGC treated plant had the highest P and K uptake. Grain yield was significantly higher for MSC (1.80 t ha^{-1}) than SWC and Control but similar to GGC (1.37 t ha^{-1}) and TWC (1.18 t ha^{-1}). Compost application at 20 t ha^{-1} significantly increased cob weight, N and K uptake of maize compared to control. Application of CPM improved final soil available P which increased with DC and rate of application of different CPM. Therefore, CPM and DC have great potentials in influencing compost quality and should be considered in formulating compost fertilizer in organic farming.

Key words: Compost quality, nutrient release, cow dung, chemical properties, composted plant materials

INTRODUCTION

Sustainable crop production could adequately be achieved by proper maintenance of soil fertility. Mineral fertilizers are used to maintain soil fertility because they provide readily available nutrient for plants. However, they lose efficiency when the soil organic matter is low. Excessive or improper use of inorganic fertilizer can lead to increase in soil acidity, leaching of nutrients, depletion of soil organic matter and degradation of soil physical properties (Plaster, 2013). Furthermore, chemical fertilizers have become unaffordable and out of reach of farmers in Nigeria and its unavailability are imperative for development of certified organic fertilizer production with the prospect of better income for farmers through organic farming and fair trade. Organic farming is an agricultural system that avoids the use of synthetic fertilizer and pesticides (Neelesh and Attika, 2015). It relies on increasing biological diversity in the field to disrupt habitat for pest organisms and the purposeful maintenance and replenishment of soil fertility (Mishra *et al.,* 2013).

Utilization of organic waste materials is fast becoming a pathway for sustainable agricultural systems that can be profitably used for replenishing soil organic matter which plays an important role in the physical, chemical and biological soil condition (Tian *et al.*, 2001; Uzoh *et al.*, 2015). A low level of soil organic matter is responsible for low crop yield and low quality of crops which in turn result to low economic returns for farmers. In recent times, there is an increase in global demand for organic food products because of its quality and the role it plays in the health of livestock and man. This leads to increased demand for readily available, easy-to-use and effective organic fertilizers (Adediran *et al.,* 2009).

Composting, a widely accepted technology for organic waste recycling in agriculture, ensures the organic matter stabilization and sanitization of these wastes. This is one method by which nutrients in

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organic wastes are recycled for crop production in order to reduce volume, particle size and humidity of organic waste, remove the biodegradable parts of organic materials thereby transforming waste into valuable soil conditioner that can be used for agricultural purposes (Khalil *et al.,* 2013). During the composting process, bacteria, fungi and other soil organisms including micro arthropods break down organic materials and transformed it into a humus-rich product called compost (Dunsin *et al.,* 2017). Compost applied as soil amendment improves soil organic matter content, water and nutrient retention in soil susceptible to leaching and stabilizes soil pH. It strengthens soil resistant to crop pest and a source of macro and micro nutrients in the soil (Kumar *et al.,* 2010). This study was therefore carried out to quantify the fertilizer value of composted plant materials vis-à-vis duration of composting on growth, yield performance of maize and soil properties.

MATERIALS AND METHODS

The experiments were carried out at Institute of Agricultural Research & Training, Moor Plantation, Ibadan in the secondary forest, located at latitude 7° 22'N and longitude 3° 50'E. This is characterized by rainfall of 1335.5 mm per annum with bimodal distribution. The annual temperature is 27.45°C and relative humidity is 77.7% (IITA, 1997).

Composting

Four different types of composts were prepared using four different composted plant materials with cow dung at the ratio of 3:1 combination of each plant material with the cattle manure. Plant materials included the following; *tridax procumbens, Panicum maximum, Chromolaena odoratum* and stovers of *Zea mays*. The plants were cut fresh from the field after which each was chopped into smaller particles of below 5 cm with chaff cutter in order to increase the surface area for decomposition. Indore hot heap method of composting the organic materials was adopted. The walls were lined with black polythene sheet and the materials were laid out in ratio 3:1 plant materials to cow dung manure (Khalil *et al.,* 2013). Each compost pile was 1.5 m in length, by 1.0 m in breadth, and 1.0 m in height. The temperature of each compost pile was monitored with the use of soil thermometer and turning was done manually with the use of garden fork whenever the temperature becomes low. Composting process proceeded for five months and each pile was sampled immediately after turning at 2, 3, 4 and 5 months (duration) of composting for nutrient analysis and screen house experiment.

Screen House Trial

The surface soil (0-15 cm) used for the trial was collected from the site where the field experiment was laid. It was air dried, sieved with 2 mm diameter mesh and sub sampled for physical and chemical analysis. Each of the plastic pot was filled with 10 kg soil and the experiment was a 4 × 5 factorial arranged in a completely randomized design (CRD) with three replicates. The factors were four types of composted plant materials, i.e., tridax weed compost (TWC), guinea grass compost (GGC), siam weed compost (SWC) and maize stover compost (MSC). Also, five durations of composting including 0, (before composting) 2, 3, 4 and 5 months (duration) of composting were used. A total of 60 pots were used for the experiment. In each pot, compost was applied at a rate of 20 t ha^{-1} equivalent and mixed thoroughly at two weeks before planting. Three seeds of quality protein maize (Obatanpa variety) were planted per pot and later thinned to two plants per pot at two weeks after planting (WAP). Watering was done daily and weed was controlled manually by uprooting whenever it emerged. Data collection commenced at 4 WAP on plant height, stem girth and number of leaves. At 6 WAP, one of the plants was carefully uprooted from each of the pot, washed with water to remove the soil and other dirt, oven-dried at 65°C till constant weight for dry matter after which it was milled to assess nutrient concentration from which nutrient uptake is calculated.

$$Y = X*C$$

where Y is % nutrient uptake, X is weight of the plant material (g), C is concentration of nutrient per plant. Final soil samples were collected randomly from each pot after harvest for laboratory analysis.

Field Experiment

The land was prepared mechanically by ploughing and harrowing and sub- sampled for physical and chemical analysis. This was a 4 × 3 factorial experiments arranged in a randomized complete block design (RCBD) replicated three times. The factors considered were; four composted plant materials (TWC, GGC, SWC and MSC), three rates of compost application (0, 10 and 20 t ha^{-1}). The plot size was 9 m^2 with a spacing of 1 m each between plots and replicates. Plant materials composted for four months were incorporated into the soil in each plot two weeks before planting. Three maize seeds were planted per hole at a spacing of 75 cm × 50 cm which were later thinned to two plants per stand at two weeks after planting. At each sampling period, four plants that had been previously tagged were used for data collection from which mean values were obtained. Data were collected on plant height, number of leaves and stem girth. At six WAP, three plants were uprooted from each of the plot, washed and separated into their various parts, oven-dried at 65°C till constant weight for determination of dry matter yield, henceforth referred to as dry matter. Weed control was carried out manually with the use of a hoe. After harvesting, the fresh and dry cob weights were determined. Soil sampling was done also from each plot after harvest.

Soil Chemical Analysis

Pre and post cropping soil samples collected from both experiments were air-dried, ground and passed through 2-mm sieve before routine analyses. They were analysed for particle size (Gee and Or, 2002), soil pH was measured in soil-water suspension 1:1 using pH meter with glass electrodes (Thomas, 1996), Organic carbon was determined by Walkley-Black procedure using dichromate as oxidizing agent (Nelson and Sommers, 1996), total nitrogen was determined by Khedhal method of Bremner (1996), available phosphorous (P) by Bray 1 method and determined colorimetrically by the method of Murphy and Riley (1962). Total acidity was by titrimetry (IITA, 1997). Effective cation exchange capacity (ECEC) was obtained as sum of total exchangeable bases and total acidity (Braize, 1998). Exchangeable bases were determined with 1 N ammonium acetate buffer at pH 7. Na^+ and K^+ in extract were determined by flame photometry and Ca^{2+} and Mg^{2+} by Automatic adsorption spectrophotometer (AAS).

Statistical Analysis

Data collected was subjected to analysis of variance (ANOVA) using statistical analysis system (SAS, 2008). The means were separated by Duncan Multiple Range Test at 5% level of probability.

RESULTS

Characteristics of Pre-Cropping Soil and Compost Used in the Study

The physical and chemical properties of the pre-cropping soil (Table 1) showed that the soil is loamy sand and moderately acidic with a pH of 5.93. Organic carbon (12.80 g kg^{-1}) and total nitrogen (1.30 g kg^{-1}) content were moderately low, while available P (5.23 mg kg^{-1}) was very low. Exchangeable basic cations ranged from very low to moderately low, exchangeable acidity was very low, the effective cation exchange capacity (ECEC) was very low. According to Aduayi *et al.* (2002), this implies that the soil was of low fertility status thus and this made it suitable for the fertilizer trial.

The pH levels of different the compost types used for the experiment (Table 2) ranged from alkaline to moderately alkaline. Guinea grass compost (GGC) had the highest pH, followed by tridax weed compost (TWC) while the least was observed in maize stover compost (MSC) and siam weed compost (SWC). Total nitrogen was highest in MSC; the values in GGC and SWC were comparable while the least was obtained in TWC. The level of total phosphorus was not significantly ($p \geq 0.05$) different among the compost types, although the two grass families (GGC and MSC) had higher values than the two broad leave group (TWC and SWC). Total potassium content was highest in GGC, followed by SWC while the least was obtained in MSC and TWC for which values were comparable.

Screen House Experiment

Interactive effects of composted plant material (CPM) and duration of composting (DC) on growth parameters of maize in screen house trial are shown in Table 3. Compost types and the duration of composting had significant ($p \leq 0.05$) effects on the growth parameters of maize at different periods of observation. At 7 weeks after planting (WAP), the tallest maize (123.93 cm) was obtained from plant that received GGC at four months DC, this was similar to all other CPM at different DC except the control which had plants with the shortest (82 cm) height. Plant that received MSC at two months DC had the highest leave count of maize (14) while the lowest leave count (6) was obtained from the control. At 4 WAP, the widest stem girth (4.17 cm) of maize was obtained from MSC at 3 months DC while the lowest stem girth (2.23 cm) was obtained from the control plot. All the other treatments had similar effects on the stem girth of maize at 4 WAP. The interaction between CPM and DC had no significant effect on stem girth at 7 WAP, as well as on maize height and leave count at 4 WAP.

The result for maize dry matter as affected by the CPM-×-DC interaction is shown in Figure 1. MSC at 4 months DC had the highest maize dry matter (6.83 g) while the lowest (2.35 g) was obtained from the control plot. All other treatment combinations resulted in comparable dry matter of maize.

Table 1: Properties of the experimental soil

Soil properties	Units	Values
pH (H_2O)	-	5.93
Organic carbon	g kg^{-1}	12.80
Total nitrogen	"	1.30
Available phosphorus	mg kg^{-1}	5.23
Exchangeable bases	cmol kg^{-1}	
K^+	"	0.27
Na^+	"	0.68
Mg^{++}	"	0.21
Ca^{++}	"	0.54
Exchangeable acidity (H^+)	"	0.11
ECEC	"	1.81
Particle size distribution	g kg^{-1}	
Sand	"	844.00
Clay	"	120.00
Silt	"	36.00
Textural class		Loamy sand

Table 2: Nutrient composition of the composts studied

Compost types	pH (H_2O)	N	P	K
		(g kg^{-1})		
Siam weed compost	8.52^c	5.9^b	7.8^a	33.03^b
Maize stover compost	8.2^c	7.0^a	8.1^a	30.02^c
Guinea grass compost	9.2^a	5.7^b	8.4^a	36.7^a
Tridax weed compost	8.9^b	4.6^c	7.8^a	30.02^c

Means values with the same letters along the column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test;
N - nitrogen; P - phosphorus; K - potassium

The soil properties at the end of the trial in the screen house experiment (Table 4) indicated that pH of the soils ranged from neutral to slightly alkaline. Soil in pots amended with GGC at four months DC and TWC at 3- and 2- months DC were significantly higher in pH than other treatment while the control pot with no compost application had the lowest pH. Available phosphorus was highest in soil amended with SWC at five months' DC while the least was found in the control pots. Maize stover compost irrespective of DC, GGC at two and four months DC and SWC at four and five months DC had significantly higher concentration of organic carbon than the other CPM and DC. Control pot had significantly lower levels of organic carbon. The exchangeable bases showed that SWC at 2 and 5-months DC had the highest levels of calcium (Ca) and potassium (K) while sodium (Na) was significantly higher in GGC at three months DC. Magnesium (Mg) was highest in MSC at four months DC and least in the control pot.

Field Experiment

The interactive effects of CPM and their rates of application on plant height and dry matter of maize under field condition are presented (Table 5). Results showed that there were no significant differences among the CPM and their application rates on the height of maize plants at 4 and 6 WAP. However, at 8 WAP, plants that received MSC at 20 t ha^{-1} had the tallest plants (169 cm) while plants grown with the control (0 t ha^{-1}) had the shortest. All the other CPM treated plants at 10 t ha^{-1} had similar heights with MSC at 20 t ha^{-1} except SWC. The control treatment generally had the shortest plants among the rates of application.

The highest maize dry matter (36.80 g plant^{-1}) was obtained at 20 t ha^{-1} application of MSC while the least was obtained from the control. Application of GGC at 10 and 20 t ha^{-1} gave comparable dry matter of maize with MSC at 20 t ha^{-1}.

Table 3: Interactive effect of composted material and composting duration on growth parameters of maize in the screen house

Treatments	Plant height (cm)		Leave count		Stem girth (cm)	
	4WAP	7WAP	4WAP	7WAP	4WAP	7WAP
SWC-2	87.90	103.10^{ab}	9.33^{a}	13.00^{ab}	3.40^{ab}	5.50^{a}
SWC-3	93.40	107.70^{ab}	8.67^{a}	12.00^{ab}	3.40^{ab}	5.23^{a}
SWC-4	95.30	111.87^{ab}	8.33^{a}	11.67^{ab}	2.87^{ab}	5.13^{a}
SWC-5	82.53	93.27^{ab}	8.33^{a}	11.33^{ab}	2.9^{ab}	4.93^{a}
MSC-2	91.17	103.53^{ab}	10.00^{a}	14.00^{a}	3.37^{ab}	5.20a
MSC-3	90.97	105.10^{ab}	9.67^{a}	13.00^{ab}	4.17^{a}	5.43^{a}
MSC-4	82.13	95.37^{ab}	8.67^{a}	13.33^{ab}	2.97^{ab}	5.30^{a}
MSC-5	89.50	104.33^{ab}	8.67^{a}	12.33^{ab}	3.8^{ab}	5.97^{a}
GGC-2	95.37	112.10^{ab}	9.00^{a}	11.00^{ab}	3.47^{ab}	5.33^{a}
GGC-3	90.93	112.20^{ab}	8.33^{a}	11.67^{ab}	3.23^{ab}	5.40^{a}
GGC-4	87.1	123.93^{a}	7.67^{a}	10.00^{ab}	3.17^{ab}	4.97^{a}
GGC-5	103.73	104.53^{ab}	8.67^{a}	12.67^{ab}	2.93^{ab}	5.77^{a}
TWC-2	75.90	92.10ab	9.00^{a}	13.33^{ab}	3.00^{ab}	5.33^{a}
TWC-3	82.33	92.63^{ab}	7.67^{a}	11.00^{ab}	3.27^{ab}	5.60^{a}
TWC-4	91.00	107.77^{ab}	8.00^{a}	11.67^{ab}	3.50^{ab}	5.97^{a}
TWC-5	95.23	109.53^{ab}	8.00^{a}	11.67^{ab}	3.33^{ab}	5.50^{a}
CNT-0	66.54	82.00^{b}	6.33^{a}	8.67^{b}	2.23^{b}	4.23^{a}

Means values with the same letters along the column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test;
SWC - siam weed compost; MSC - maize stover compost; GGC - guinea grass compost; TWC - tridax weed compost; CNT - Control;
2, 3, 4 and 5 months of composting; WAP - weeks after planting

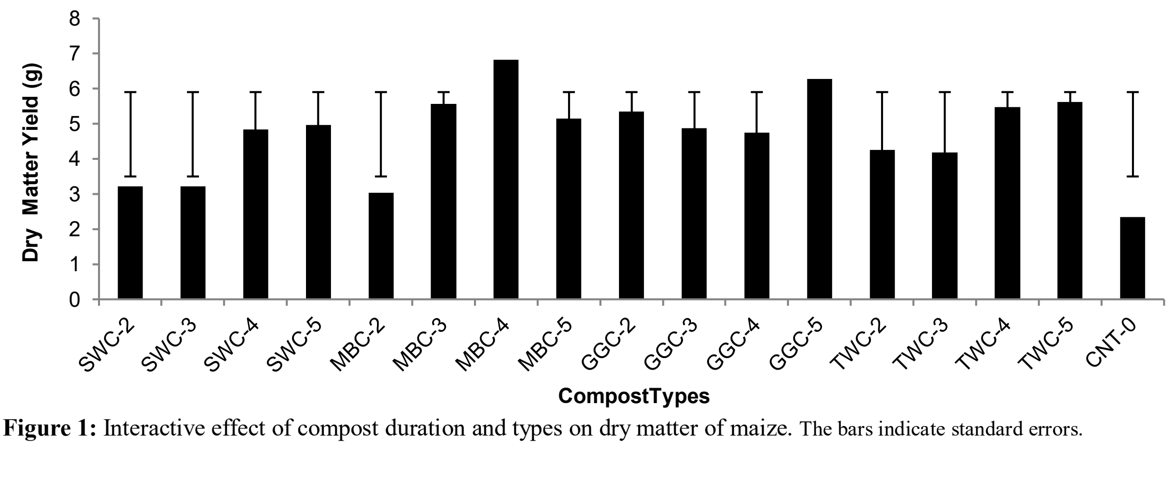

Figure 1: Interactive effect of compost duration and types on dry matter of maize. The bars indicate standard errors.

Table 4: Chemical properties of screen house soil after harvest

Treat-ments	pH	Av. P (mg kg^{-1})	OC (g kg^{-1})	Tot N (g kg^{-1})	Ca^{++} (c mol kg^{-1})	Na^{+}	Mg^{++}	K^{+}	H^{+}	ECEC
SWC-2	6.98^{bc}	15.30^{ac}	4.60^{b}	5.00^{b}	13.74^{a}	0.93^{abc}	0.18^{abc}	1.81^{a}	0.06^{ab}	14.03^{a}
SWC-3	7.23^{ab}	13.42^{bc}	7.70^{b}	8.00^{b}	11.06^{ab}	0.72^{dc}	0.22^{ab}	1.25^{ab}	0.05^{bc}	15.98^{a}
SWC-4	7.10^{abc}	25.61^{ab}	13.70^{a}	14.00^{a}	7.27^{ab}	0.79^{bdc}	0.20^{ab}	0.67^{ab}	0.06^{abc}	$9.00d^{c}$
SWC-5	7.33^{ab}	31.20^{a}	11.50^{a}	12.00^{a}	11.69^{a}	0.86^{abcd}	0.08^{bc}	0.76^{ab}	0.04^{bc}	13.43^{ab}
MSC-2	7.17^{ab}	10.40^{bc}	13.20^{a}	13.00^{a}	10.29^{ab}	0.87^{abcd}	0.18^{abc}	1.38^{ab}	0.05^{bc}	12.77^{b}
MSC-3	7.27^{ab}	23.10^{ab}	11.50^{a}	11.00^{a}	9.75^{ab}	0.84^{abcd}	0.24^{ab}	1.18^{ab}	0.05^{bc}	12.06^{bc}
MSC-4	7.24^{ab}	14.00^{bc}	10.00^{a}	10.00^{a}	10.19^{ab}	0.79^{bdc}	0.33^{a}	1.01^{ab}	0.05^{bc}	12.36^{b}
MSC-5	7.06^{abc}	13.27^{bc}	9.70^{ab}	10.00^{a}	9.75^{ab}	0.80^{bdc}	0.16^{abc}	0.98^{ab}	0.06^{abc}	11.76^{bc}
GGC-2	7.09^{abc}	11.68^{bc}	10.80^{a}	11.00^{a}	11.06^{ab}	0.88^{abcd}	0.21^{ab}	1.30^{ab}	0.06^{abc}	13.51^{ab}
GGC-3	7.39^{ab}	15.65^{abc}	8.70^{ab}	9.00^{ab}	8.15^{ab}	1.08^{a}	0.14^{bc}	1.01^{ab}	0.04^{bc}	10.42^{c}
GGC-4	7.50^{a}	13.65^{bc}	10.00^{a}	10.00^{a}	7.02^{ab}	0.99^{ab}	0.16^{ab}	0.59^{ab}	0.03^{c}	8.79^{d}
GGC-5	7.34^{ab}	11.37^{bc}	6.40^{b}	6.00^{b}	6.88^{ab}	0.80^{bdc}	0.16^{ab}	0.94^{ab}	0.04^{bc}	8.83^{d}
TBC-2	7.50^{a}	20.58^{abc}	7.00^{b}	7.00^{b}	10.49^{ab}	0.75^{bcd}	0.14^{ab}	1.16^{ab}	0.04^{c}	12.58^{b}
TWC-3	7.47^{a}	26.50^{ab}	8.00^{ab}	8.00^{ab}	11.64^{a}	0.77^{bdc}	0.18^{abc}	0.67^{ab}	0.04^{c}	13.29^{ab}
TWC-4	7.40^{ab}	15.39^{abc}	6.60^{b}	7.00^{b}	9.60^{ab}	0.71^{cd}	0.19^{abc}	0.91^{ab}	0.04^{c}	11.44^{bc}
TWC-5	7.27^{ab}	13.58^{bc}	6.90^{b}	7.00^{b}	9.54^{ab}	0.78^{bcd}	0.17^{ab}	0.95^{ab}	0.05^{bc}	11.49^{bc}
CNT-0	6.68^{c}	4.95^{c}	5.00^{b}	5.00^{b}	3.83^{b}	0.64^{d}	0.05^{c}	0.36^{b}	0.08^{a}	4.92^{e}

Mean values with the same letters within the same column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test; SWC - siam weed compost; MSC - maize stover compost; GGC - guinea grass compost; TWC - tridax weed compost; CNT - control; 2, 3, 4 & 5 months of composting; Av. P - available phosphorus; OC - organic carbon; Tot N - total nitrogen; ECEC - effective cation exchange capacity

The effect of composted plant materials on yield and nutrient uptake by maize is presented in Table 6. Results showed that plants that received MSC had significantly higher ($p \leq 0.05$) grain yield (1.80 t ha^{-1}) than all the other compost treated plants. However, GGC (1.37 t ha^{-1}) and TWC (1.18 t ha^{-1}) treated plants had comparable grain yield with MSC followed by SWC (1.04 t ha^{-1}) and the control (0.91 t ha^{-1}) which had the lowest yield.

Nitrogen uptake was highest in plants that received MSC (2.92 g kg^{-1}) and least in the control (1.19 g kg^{-1}). However, N uptake from plant treated with all other compost types were not significantly different. The plants treated with GGC had the highest P uptake (0.71 g kg^{-1}) followed by MSC (0.68 g kg^{-1}) and TWC (0.62 g kg^{-1}) and the least in control (0.40 g kg^{-1}). The uptake of K followed the same trend as that of P uptake; plants treated with GGC had the highest K uptake (5.86 g kg^{-1}) followed by MSC (4.80 g kg^{-1}) and TWC (4.72 g kg^{-1}); control (2.80 g kg^{-1}) had the least K uptake.

The mean effects of rates of application of CPM on yield and nutrient uptake by maize presented in Table 7 shows that plant treated with 20 t ha^{-1} of CPM had the highest fresh cob weight (4.53 t ha^{-1}) while control (3.10 t ha^{-1}) had the least fresh cob weight. Also, plant treated with 20 t ha^{-1} CPM had the highest dry cob weight (2.43 t ha^{-1}) and grain yield (1.74 t ha^{-1}) respectively while the least dry cob weight (1.67 t ha^{-1}) and grain yield (0.88 t ha^{-1}) were obtained in control. The N uptake of plant treated with 20 t ha^{-1} CPM (2.38 g kg^{-1}) was not higher than that of 10 t ha^{-1} CPM (2.0 g kg^{-1}) but significantly higher than the control (1.14 g kg^{-1}). There was no significant difference in the P uptake of maize among treatments. However, plants treated with 20 t ha^{-1} CPM was higher in K uptake (6.91 g kg^{-1}) and the least was obtained from the control (4.34 g kg^{-1}).

The effect of CPM and the rate of application on soil used for the experiment after harvesting shown in Table 8 shows that there were no significant differences in the pH, organic carbon, total nitrogen and exchangeable bases (K, Ca and Mg) of the soil across all the treatments. However, the available phosphorus concentration was highest ($p \leq 0.05$) in the plots that were treated with 20 t ha^{-1} of SWC (18.7 mg kg^{-1}) and TWC (12.9 mg kg^{-1}) compared to the other treatments. Plots treated with 20 t ha^{-1} TWC had the highest effective cation exchange capacity (2.93 cmol kg^{-1}) which was not significantly higher than other compost treatments but significantly higher than the control.

Table 5: Growth and dry matter of maize under field condition

Treatments (t ha^{-1})		Plant height (cm) 4 WAP	6 WAP	8 WAP	Dry matter (g plant^{-1})
Siam weed compost	0	40^{a}	71^{a}	95^{c}	16.40^{c}
	10	45^{a}	90^{a}	130^{b}	22.50^{b}
	20	53^{a}	116^{a}	163^{a}	27.90^{b}
Maize stover compost	0	54^{a}	123^{a}	99^{c}	20.10^{b}
	10	55^{a}	111^{a}	155^{ab}	29.60^{b}
	20	57^{a}	130^{a}	169^{a}	36.80^{a}
Guinea grass compost	0	50^{a}	80^{a}	98^{c}	22.80^{b}
	10	53^{a}	114^{a}	144^{ab}	33.60^{a}
	20	57^{a}	118^{a}	166^{a}	31.80^{a}
Tridax weed compost	0	53^{a}	71^{a}	109^{bc}	18.40^{c}
	10	46^{a}	97^{a}	141^{ab}	27.00^{b}
	20	53^{a}	110^{a}	152^{ab}	24.00^{b}

Mean values with the same letters within the same column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test; WAP - weeks after planting

Table 6: Mean effect of composted plant materials on yield and nutrient uptake by maize

Compost types	Fresh cob weight	Dry cob weight	Grain yield	N-uptake	P-uptake	K-uptake
		yield (t ha^{-1})			(kg ha^{-1})	
Maize stover compost	4.51^{a}	2.52^{a}	1.80^{a}	5840^{a}	1360^{a}	9600^{a}
Guinean grass compost	3.91^{ab}	2.08^{ab}	1.37^{ab}	5740^{a}	1420^{a}	11720^{a}
Tridax weed compost	3.2^{ab}	1.76^{ab}	1.18^{ab}	5100^{ab}	1240^{a}	9440^{a}
Siam weed compost	3.09^{b}	1.79^{b}	1.04^{b}	4820^{ab}	880^{b}	7060^{b}
Control (no compost)	2.84^{c}	1.4^{c}	0.91^{c}	2380^{b}	800^{b}	5600^{c}

Means values with the same letters along the column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test;
N - nitrogen; P - phosphorus; K - potassium

Table 7: Mean effect of rate of application of compost on yield and nutrient uptake by maize

Rate of compost application (t ha^{-1})	Fresh cob weight	Dry cob weight	Grain yield	N-uptake	P-uptake	K-uptake
		yield (t ha^{-1})			(kg ha^{-1})	
0	3.10^{b}	1.67^{b}	0.88^{b}	2280^{b}	2720^{a}	8680^{b}
10	3.19^{b}	1.79^{ab}	1.32^{ab}	4160^{a}	2920^{a}	10080^{b}
20	4.53^{a}	2.43^{a}	1.74^{a}	4760^{a}	4580^{a}	13820^{a}

Means values with the same letters along the column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test;
N - nitrogen; P - phosphorus; K - potassium

Table 8: Chemical properties of soil after harvest

Treatments (t ha^{-1})		pH	OC	Tot N	Av. P	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	H^{+}	ECEC
			(g kg^{-1})		(mg kg^{-1})			(cmol kg^{-1})			
Siam weed compost	0	6.09^{a}	4.9^{a}	5.0^{a}	1.54^{c}	0.88^{ab}	0.43	0.96	0.03	0.00^{b}	2.3^{ab}
	10	6.15^{a}	3.2^{a}	3.0^{a}	7.35^{b}	0.89^{ab}	0.55	0.96	0.03	0.02^{b}	2.46^{ab}
	20	6.38^{a}	4.5^{a}	5.0^{a}	18.7^{a}	0.87^{ab}	0.59	1.12	0.03	0.34^{a}	2.65^{ab}
Maize stover compost	0	6.09^{a}	3.2^{a}	3.0^{a}	4.47^{bc}	0.74^{b}	0.35	0.91	0.28	0.00^{b}	2.03^{b}
	10	5.9^{a}	4.7^{a}	5.0^{a}	3.66^{bc}	0.87^{ab}	0.41	1.06	0.34	0.00^{b}	2.37^{ab}
	20	5.96^{a}	3.9^{a}	4.0^{a}	9.89^{b}	0.92^{ab}	0.42	1.18	0.33	0.39^{a}	2.59^{ab}
Guinea grass compost	0	6.06^{a}	2.5^{a}	3.0^{a}	4.44^{bc}	0.81^{b}	0.43	0.99	0.33	0.00^{b}	2.26^{b}
	10	6.35^{a}	3.9^{a}	4.0^{a}	4.26^{bc}	0.81^{b}	0.48	1.31	0.33	0.00^{b}	2.64^{ab}
	20	6.38^{a}	4.4^{a}	4.0^{a}	9.51^{b}	0.91^{ab}	0.44	1.2	0.34	0.00^{b}	2.58^{ab}
Tridax weed compost	0	6.1^{a}	4.5^{a}	5.0^{a}	2.74^{c}	0.87^{ab}	0.43	1.11	0.33	0.00^{b}	2.45^{ab}
	10	6.35^{a}	4.2^{a}	4.0^{a}	9.68^{b}	0.86^{ab}	0.66	1.18	0.33	0.00^{b}	2.75^{a}
	20	6.45^{a}	4.7^{a}	0.5^{a}	12.95a	1.10^{a}	0.47	1.32	0.34	0.00^{b}	2.93^{a}

Mean values with the same letters within the same column are not statistically different ($p \geq 0.05$) by Duncan Multiple Range Test;
OC - organic carbon; Tot N - total nitrogen; Av. P - available phosphorus; ECEC - effective cation exchange capacity

DISCUSSION

The soil used for both screenhouse and field experiments is a Typic Kanhaplustalf (Soil Survey Staff, 2013) and locally classified as Iwo series (Nwachokor and Uzu, 2008); gravelly soil derived from coarse grained, granite and gneiss which is classifield in the order of Alfisol (Harpstead, 1974). The test soil was low in fertility, due to the continuous use of the land for cropping. This is in agreement with Mbagwu and Obi (2003) in their research work that most tropical soils are depleted of nutrients especially when crop demands were high. Aduayi *et al.* (2002) observed that most Nigerian soils are deficient in the primary major essential nutrients required by plants, and Omisore and Abayomi (2016) reported that sustainability method of improving these soils is by fertilizer application which in this research was organic type.

Highest values of growth parameters of maize obtained from CPMs than control plot could be attributed to availability of essential nutrients required for plant growth in the four CPM than control. Timely application of compost probably ensured availability these nutrients for good plant growth as it was observed in the vegetative period, i.e., six weeks after planting maize. Adetunji (1995) in his research on organic residue management on soil nutrient changes and maize yield stated that nitrogen is involved in high vegetative growth that could translate to higher yield if it is supplied at the right time. Also, Abd El-Gawad and Morsy (2017) concluded that application of organic fertilizer (sheep manure + compost (10 t fed^{-1}) + (50 kg fed^{-1}) Urea should be adopted since it achieved the highest growth, yield, yield components and quality of maize crop (var., Hi-284 Tech 1100) as well as soil properties under Assiut condition.

Application of compost had significant effect on crop vegetative growth, dry matter weight and grain yield. (Adeyeye *et al.,* 2014). Among different CPM applied, GGC and MSC performed better than others. The high growth rate observed could be due to the formation of more humic substances which resulted from the degradation of more recalcitrant organic substrates over time by the microorganisms; humic substances are prominent in accelerating root respiration, formation and growth (Serra–Wittling *et al.,*1996; Adejumo *et al.,* 2010). Baris *et al.* (2009) observed that the effect of humic substances on wheat plant under salinity condition could result in increased efficiency of the plant rooting system, which in turn improves the upper growth of plants such as shoots, leaves, flowers and fruit yield. Aisha *et al.* (2014) corroborated the findings that increasing humic acid increased growth parameters, yield components and protein percentage of crop.

Guinea grass and maize stover composts were outstanding in their influence on maize growth, nutrient uptake and yield performance both in the screen house and under field condition. This may be because MSC had the highest N while GGC had the highest K nutrient composition than other two CPMs. They however contained nutrients in proportion similar to that which will enhance nutrient balance for uptake by maize crop. Compost applied at 20 t ha^{-1} enhanced maize growth, grain yield, dry matter, and nutrient uptake, though it was comparable to 10 t ha^{-1}. Abou-ELMagad *et al.* (2005) found that nutrients contained in organic fertilizer (manure) improved root development and higher yield of crop. Optimum soybean grain yield was obtained from application of 2 or 4 t ha^{-1} of compost (Adeyeye *et al.,* 2014). Although SWC encouraged better vegetative growth at 20 t ha^{-1}, its effect on grain yield was poor. The result showed that compost materials may be selected based on the desired crop performance in terms of vegetative growth or grain yield, thus SWC application may be better for leafy vegetable production.

Analysis of soil after harvesting of maize in both screen house and field experiments showed that application of compost improved soil properties. This is a major advantage of the use of organic fertilizers for crop production (Babalola *et al.,* 2012). Azeez and Adetunji (2004) found the effect of compost to be significant on phosphorus which is one element whose availability is low due to its fixation by aluminum and iron in the soil. The significant effects of P uptake by maize among the CPM used and that of the available P in soil after harvest showed that the quality of organic matter in the compost influenced P availability in soil (Ojo *et al.,* 2010). Venhaus *et al.* (2005) also confirmed that P concentration in the soil treated with compost are up to 2.6 times greater than the soil treated with inorganic fertilizer after two years of application.

CONCLUSION

Plant materials for composting and durations of composting affected the chemical properties of the compost and soil properties after harvest. Maize performance was affected by the type of compost. Compost made from maize (MS) of 3- and 4-month DC and guinea grass (GG) of 4 and 5 months DC performed better than other CPM and DC of this study. It is recommended that, in compost preparation, the plant materials to be used and the duration of the composting should be carefully considered so as to obtain the desired composition.

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