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Full Length Research Paper

Effect of organic waste compost and microbial activity on the growth of maize in the utisoils in Port Harcourt, Nigeria

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One of the major problems of agricultural soils in the coastal areas of the Niger Delta is the low organic matter content. Therefore, land application of composted organic material as a fertilizer source not only provides essential nutrients to plants, it also improves soil quality and effectively disposes soil wastes. In this study, poultry droppings, spent mushroom wastes, earthworm casts and soil samples were collected from the agriculture farm of the University and composted for 21 days. The composts were applied as nutrient supplements to maize crops at different concentrations of 3000, 9000, 18000 t/ha and control, to determine their effect on crop yield. The patterns of organic waste composting were compared among various combinations. The results obtained showed that organic waste compost application improved soil physical properties, increased nitrogen content, phosphorus, potassium and some micronutrients such as zinc, iron and copper. Vegetative growth parameters were better enhanced in maize stem length, girth, number of leaves and chlorophyll content while other nutrient combinations showed improved yields, especially Soil + spent mushroom wastes (SMW) + poultry droppings (PW) at 40 t/ha. Microorganisms involved in the breakdown of composts were isolated and characterized according to various biochemical reactions. They include *Bacillus subtilis, Proteus vulgaris, Pseudomonas, Corynebacterium* and *Enterobacter species*. Therefore, management of organic wastes through composting increases soil organic matter and other nutrients, and therefore had the added benefit of improving soil quality and thereby enhancing long term sustainability of agriculture. Their use also enhances microbial activities which enhances nutrient supply.

Key words: Composts, organic wastes, inorganic fertilizers, microbial activities, soil, maize, nutrient content.

INTRODUCTION

Wastes are generated by activities in all economic sectors and also by goods consumption. In general, wastes are regarded as unavoidable by-products of economic activity, as wastes are generated from production processes or low durability of goods and unsustainable consumption pattern. Waste quantities are growing and increased concerns in environmental protection and management stimulated interest in recycling wastes from the agricultural, industrial and municipal sectors of our society. The increase in waste production is the result of human population growing and its concentration in urban areas, concentrated animal production in some areas and expanding diversifying industrial activities (Felipo et al., 2004; Ogbonna et al., 2007; Adeleye et al., 2010). Several workers have reported the use of several organic materials especially cow dung,

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poultry droppings, refuse compost, farm yard manure and biohumus as soil amendment substrates, suitable for increasing crop production particularly among sub-sistence farmers in West Africa (Amadi and Ile Bari, 1992; Amadi et al., 1993; Obire and Akinde, 2004; Adegunloye et al., 2007; Mbonu, 2007).

Among the different sources of organic manure which have been used in crop production, poultry manure is found to be the most concentrated in terms of nutrient content (Yayock and Awoniyi, 1974; Fabiyi and Ogunfowora, 1992; Obire and Akinde, 2004, 2005, 2006). These authors observed that manure application improved the availability of some minerals in the soil, especially the transfer of nutrients from range land to the crop plants. Reports also show that these materials influence crop yield and affect chlorophyll coloration, due to the amount of nutrients absorbed by the plant from the soil. In addition to supplying plant nutrients, they improve the physical properties of the soil (Amujoyegbe et al., 2007; Adeleye et al., 2010) and enhance the soil microbial activities which enhance nutrient supply (Udoh et al., 2005).

In another development, the soil is the home of myriads of organisms where they find their means of sustenance and participate in the soil forming process. Several groups of the soil fauna, such as the earthworms, play vital roles in the biochemical processes involved in decomposition of organic materials and nutrient cycling (Adejuyigbe and Akanji, 2005). Their population in the soil is also influenced by the environmental condition of the soils as well as its management. Earthworms are known to improve soil aeration and water infiltration in agro ecosystems by tunneling through the soil (Ikpe et al., 2003). One prominent feature of earthworm activity in the soil is the cast which the worms deposit at the soil surface.Considering the need to divert increasing amounts of these biodegradable wastes from various dumpsites in the urban city centres, more emphasis needs to be placed on composting suitable wastes, such as poultry droppings, spent mushroom wastes and botanical wastes etc., into high specification wastes; a derived compost predicated to be a replacement material for fertilizers as growing media. This is because the use of inorganic fertilizers on arable soils leads to serious decline in soil fertility, increase soil acidity, nutrient leaching and degradation of soil organic matter and soil physical conditions (Nottidge et al., 2005). Although at present, there are no sufficient markets for the relative small volume of composted material that is produced because of high importation of fertilizers in Nigeria, there is a pressing need to investigate ways of adding value to compost, in order to expand future markets. This study therefore sought to address the potential for transforming organic waste materials from agricultural processes, into high specification compost to replace inorganic fertilizers as growing media for crops in Nigeria. It also investigated the performance of an innovative combined composting system as a means of producing added-value compost.

MATERIALS AND METHODS

Site description

The research was carried out at the Department of Applied and Environmental Biology (behind the green house) of the Rivers State University of Science and Technology, Nkpolu, Port Harcourt. The annual rainfall pattern is bimodal, starting from March and ending in November with peaks in June and September, and a short period of lower precipitation in August, generally referred to as “August Break”. The main annual rainfall ranges from about 3000 to 4000 mm (FAO, 1984) while the annual temperature ranges from an average minimum of 21°C to average maximum of 31°C (FDRD, 1981).

Collection of samples

The following materials were used for the study:

a) Spent mushroom waste was collected from Dilomat mushroom Development Centre, Rivers State University of Science and Technology (RUST). The spent mushroom waste is not usually used fresh from the mushroom house for crop production, but it is usually processed to reduce the soluble salts (Guo et al., 2001; Ewuzie, 2009);
b) Poultry manure was obtained from the Research Farm of the Faculty of Agriculture, RUST and was treated by allowing it to air-dry for two days, before it was used. Similar treatment was done for the spent mushroom waste before use;
c) Earthworm casts and soil samples; all samples obtained for the study were analysed to ascertain their chemical properties before use in the composting process (Table 1) and;
d) Local variety of maize was purchased from Mile 1 market, Diobu, Port Harcourt. This was used as the planting material.

Field experiments

A silo was made and used for the recycling of organic wastes (poultry droppings (PW), spent mushroom wastes (SMW), earthworm casts (EC) etc.). The various treatments used were mixed in combinations to make compost in the ratio of 2:2:1, respectively as follows: 20 t/ha SMW; 20 t/ha PW and 10 t/ha EC. Then, the organic wastes and the soil samples were weighed out (500 g), thoroughly mixed in the silo and moistened to 70% field capacity with water (Ano and Agwu, 2006). Composting in the silo was done for 21 days, under controlled temperature and aeration (Zahir et al., 2007a). Soil samples (3 kg) were then weighed into each 20 size plastic planting buckets. The experiment involved 7 treatments in a randomized complete block design of 28 plots, replicated 3 times. Quantities of the manures equivalent to 0 (Control), 3, 9 and 18 t/ha were weighed in four replicates into the buckets. The soil and compost manures were thoroughly mixed and moistened to 70% field capacity. Planting of maize seeds were carried out 24 h after incorporation of the treatment (Amujoyegbe et al., 2007). The treatment combinations consist of A = Control with no nutrient supplement; B = Compost (recommended doses: (a) 3000 t/ha; (b) 9000 t/ha and; (c) 18000 t/ha); C = Soil + SMW + PW; D = Soil + SMW + EC; E = Soil + PW and; G = Soil + SMW and Soil + EC at various rates of application/proportions. Six seeds were planted per pot but seedlings were thinned to three seedlings after 2 weeks of growth. The pots were watered at an interval of 2 days, up to about their field capacity throughout the growing season. Weeding was done by hand picking. All weeds were

Table 1. Chemical characterization of organic wastes used in the trials.

Parameter	Soil	PM	EC	SMW
pH	5.10	6.05	5.95	6.32
Organic compound (%)	2.04	2.50	2.43	2.70
Phosphate (mg/kg)	2.27	19.13	13.40	12.95
Total nitrogen (%)	0.15	0.29	0.37	0.24
C/N ratio	14.37	8.62	6.57	11.25
Potassium (mg/kg)	39.36	48.23	39.45	29.0
Sodium (mg/kg)	17.91	17.82	12.85	9.95
Calcuim (mg/kg)	33.31	39.04	30.08	40.23
Magnesium (mg/kg)	32.41	38.25	36.03	35.14
Iron (mg/kg)	72.04	0.04	5.05	0.007
Manganese (mg/kg)	25.71	0.003	<0.001	<0.001
Soil texture	Sandy loam	-	-	-

PM = Poultry manure; EC = earthworm cast and; SMW = spent mushroom wastes.

deposited on their respective pots to decompose. Growth parameters, such as plant height, number of leaves and chlorophyll content estimation, were measured weekly as from 2 weeks after planting (WAP) over another 6 weeks period.

After nutrient application, the treated and untreated (control) pots was left undisturbed for another 4 weeks, except for intermittent watering, at an interval of 4 days. Plant height in centimeters (cm) was measured, using a meter rule. Leaf area in cm^2 was accessed by measuring the total length and breadth (at the broadest point) of the longest leaf, on the same plant and multiplying the factor.

Chlorophyll content estimation

Leaf samples from the maize crop were harvested for chlorophyll content estimation following the methods of Bansal et al. (1999). One hundred milligram (100 mg) fresh leaf sample was crushed/mashed in 20 ml of 80% acetone and the extract centrifuged for 10 min at 1000 rpm. Absorbance of the supernatant was recorded at 645 and 663 nm in a CL-24 spectrophotometer. Chlorophyll content (expressed as mg/g of each sample) was estimated according to the method of Bansal et al. (1999) as follows:

$$\text{Chlorophyll a (mg/g)} = 12.7\ (A663) - 2.69\ (A645) \times vw$$

$$\text{Chlorophyll b (mg/g)} = 22.9\ (A645) - 4.86\ (A663) \times vw$$

$$\text{Total chlorophyll t (mg/g)} = [20.2\ (A645) - 8.02\ (A663) \times vw] / 1000$$

Where, A is the absorbance at the given wavelength; W is the weight of fresh leaf sample and and V is the final volume of chlorophyll solution.

Chlorophyll stability index (CSI) was determined as outlined by Sivasubramaniawn (1992). Two grams (2 g) of fresh leaf was taken and divided into 2 lots of one gram (1 g) each. One lot was stored at room temperature (26°C) and the other was put in an empty test tube standing in boiling water bath for one hour. The chlorophyll content of the two lots was extracted as described earlier.

Microbiological analysis

One gram each of the samples were aseptically transferred into a sterile test-tube containing 9.0 ml diluents (normal saline) as described by Akinde and Obire (2008). Subsequently, six fold (10^{-6}) serial dilutions were prepared from the 10^{-1} dilution. A 0.1 ml aliquot of 10^{-4} dilution was aseptically removed with a sterile pipette and spread on well dried nutrient agar (Oxoid CM3) plates. The inoculated plates were incubated at 37°C for 24 to 48 h, after which the plates were examined (Ogbonna and Igbenijie, 2006) for growth.

Discrete colonies were sub-cultured onto nutrient agar plates for the development of pure isolates, which was stored on nutrient agar slants for subsequent characterization and identification on the basis of their cultural, morphological, and physiological characteristics. The presumptive identification of isolates was done with reference to Bergey's Manual of Determinative Bacteriology (Holt et al., 1994).

Determination of soil physical properties

Soil bulk density was determined from oven dried undistributed core samples, collected to the depth of 10 cm by core method (Stolte et al., 1992). Total porosity (Ps) was calculated from bulk density (Db), assuming a particle density (Dp) of 2.65 g/cm^3, using the relationship between particle density (Dp) and bulk density (Db) that is, Ps = 100 (1 - Db/Dp). Soil temperature was measured using a soil thermometer inserted to 10 cm depth. Soil moisture content was measured with the TDR-100 moisture meter. The soil physical properties were measured a month after the treatments were applied and at a 4-weekly intervals.

Determination of soil chemical properties

Soil samples from 0 to 30 cm depth and organic waste materials were collected, ground and passed through 2 mm sieve. Both samples were analyzed for physical and chemical characteristics, according to the methods described by Isirimah et al. (2003). Organic waste materials were air- dried for two days to remove excessive moisture and sorted out to remove unwanted materials. The sorted organic waste material was oven-dried at 65°C for 24 h and ground into fine particles. Soil pH was determined, using the Eil model 720 pH meters, by dipping the electrode into a 1.2.5 soil/water suspension. Total nitrogen was determined by the Kjeidahl method, while available phosphorus was extracted by the Bray-1method and determined colorimetrically. Exchangeable cations were determined after extraction of soils with IN ammonium

Table 2. Effect of organic wastes on soil physical properties.

Treatment (t/ha compost manure)	Moisture content (mg/kg)	Temperature (°C)	Bulk density (g/cm^3)	Total porosity (%)
0	54.34±3.40[a]	31.50±0.707[a]	1.39± 0.042[a]	46.85±2.546[a]
3000	72.10±2.376[b]	31.48±0.870[a]	1.35±0.014[a]	43.77±3.734[a]
9000	72.70±2.708[b]	31.60±0.566[a]	1.45±0.156[a]	41.92±2.178[a]
18000	73.11±6.237[b]	31.24±0.771[a]	1.40±0.049[a]	46.41±3.726[a]
Total	68.06±8.998	31.46±.574	1.40±0.074	44.74±3.191

Means with the same superscript are similar for the various treatments.

acetate for 1h. The Na, K and Ca in the filtrate were determined using flame photometer, while Mn and Fe were determined using atomic absorption spectrometer. Organic carbon in the soils was determined by the Walkley-Black dichromate oxidation method as amended by Adeleye et al. (2010).

Growth and yield data

Maize stands from the various plots were selected for the measurement of growth and yield parameters at harvest, according to the methods adopted by Adeleye et al. (2010). Stem girth/diameter was measured at 15 cm above heap level, using a pair of vernier calipers. The stem length was measured with a measuring tape. The number of leaves per plant was recorded.

Data analysis

Data on the soil physical, soil chemical and plant growth were subjected to analysis of variance, using Statistical Analysis System Institute Package (SAS) and the mean values were compared, using the Least Significant Difference (LSD) at $P < 0.05$.

RESULTS

Effect of organic wastes on soil physical properties

Data obtained from the application of the composted organic wastes on the crops indicated that as the compost application rates were increased from 0 to 18,000 tonnes, considerable improvement in moisture content and other soil quality parameters occurred (Table 2).

Moisture content had 54.34 ± 3.40 mg/kg at 0 t/ha manure treatment, while 73.11 ± 6.25 mg/kg was recorded for 18000 t/ha manure application. This shows that there was significant difference (at 0.05%) with the organic matter amendments. Similar results were observed for bulk density and total porosity parameters. Bulk density had 1.39 ± 0.042 g/cm^3 at 0 t/ha and 1.45 ± 0.156 g/cm^3 on application of 9000 t/ha compost manure. Temperatures ranged between 31.60 ± 0.566°C at 9000 t/ha manure application; which shows that at 0.05%, there was no significant difference observed during the treatment.

Effect of organic wastes materials on soil chemical properties

Table 3 shows the influence of composted manure on soil chemical properties. Application of composted manure increased soil pH, organic matter content, total N_2, available phosphorous, exchangeable cation (ca) and cation exchange capacity slightly. It reduced the concentration of micro nutrients when compared with plots without composted manure. However, the improvements in the soil chemical characteristics of plots amended with composted manure when compared with plots without manure application were more pronounced. Available phosphorous had 45.23 ± 1.09 mg/kg on application of composted manure and 20.64 ± 2.88 mg/kg on plots without composted manure. Manganese (Mn) had 41.6 ± 0.566 mg/kg on plots without composted manure and was reduced to 3.38 ± 0.283 mg/kg when treated with composted manure. However, application of composted manure increased Fe and Zn contents. Iron (Fe) content increased from 5.92 ± 0.198 to 7.01 ± 0.778 mg/kg on application of manure, while Zinc increased from 7.85 ± 0.31 to 8.43 ± 1.45 mg/kg. Therefore, available phosphorous, iron and zinc contents were significantly ($p < 0.05$) influenced by the application of amended organic wastes.

Effect of organic wastes on plant performance

Table 4 shows the influence of composted organic wastes on the vegetative parameters of maize. The vegetative parameters of maize were significantly ($p < 0.05$) influenced by the application of composted organic wastes at different concentrations. Vegetative growth parameters were better enhanced in plots amended with compost manure than plots without compost manure application. Application of amended organic wastes increased maize stem length, girth, number of leaves, leaf length and chlorophyll content.

This shows that there was an influence of composted organic wastes on leaf nutrients of maize when compared to leaf nutrients of plots without composted organic wastes manure application. In addition to yield increase,

Table 3. Effect of organic wastes on soil chemical properties.

Compost manure (t/ha)	pH	Organic matter	Total N_2 (mg/kg)	Available P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	CEC (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
No manure (control)	5.96±0.70	3.12±0.707	0.39±0.071	0.39±0.071	0.78±0.240	1.43±0.262	0.58±0.049	0.24±0.007	3.54±0.085	4.16±0.566	5.92±0.198	3.73±0.177	7.85±0.311
3000	5.96±0.10	3.23±0.269	0.45±0.028	31.15±8.13^{a}	0.92±0.014	1.61±0.191	0.60±0.113	0.20±0.014	3.84±0.516	3.84±0.516	4.60±0.658	6.40±0.212	8.98±0.45
9000	6.12±0.12	3.15±0.212	0.37±0.085	28.40±4.38^{a}	0.98±0.028	1.54±0.276	0.43±0.339	0.22±0.014	3.86±0.629	4.09±0.099	6.60±0.849	3.16±0.156	8.83±0.106
18000	6.20±0.28	3.76±0.62	2.76±3.18	45.23±1.09^{b}	1.27±0.09	1.21±0.035	0.54±0.03	0 .23±0.03	3.84±0.03	3.38±0.283	7.01±0.778	3.61±0.62	8.43±1.45
Total	6.06±0.31	3.32±0.470	0.99±1.62	31.35±10.19	0.99±0.22	1.45±0.23	0.54±0.15	0.22±0.02	0.22±0.02	4.06±0.58	6.48±0.614	3.39±0.408	8.52±0.750

Table 4. Effect of organic wastes on plant performance characteristics (maize).

Treatment	Stem length	Stem girth diameter	Number of leaves	Leaf length	Leaf width	Chlorophyll content
No manure (control)	72.00±8.49^{a}	2.72±0.06^{bcd}	8.00±1.41^{ab}	81.00±4.24^{ab}	27.00±1.41^{abc}	1.61±0.23^{a}
3000 (t/ha/compost manure)	170.50±7.78^{c}	2.79±0.01^{bcd}	14.00±2.83^{cde}	98.50±9.19^{b}	30.50±4.95^{bc}	2.43±0.24^{a}
9000 (t/ha/compost manure)	207.0±5.66^{d}	2.88±0.02^{d}	17.00±1.44^{de}	108.50±17.67^{b}	35.00±1.41^{c}	2.99±0.41^{a}
18000 (t/ha/compost manure)	189.50±12.02^{cd}	2.82±0.08^{cd}	19.00±2.82^{e}	101.50±7.78^{b}	28.50±6.36^{bc}	2.87± 0.58^{a}
Soil + EC (20 t/ha)	85.00±14.14^{a}	2.33±0.25^{a}	5.50±0.71^{a}	52.50±7.78^{a}	15.50±0.71^{a}	1.23±0.33^{a}
Soil + PM (20 t/ha)	110.50±6.36^{b}	2.48±0.03^{ab}	9.50±0.71^{abc}	71.50±19.09^{ab}	25.00±1.41^{abc}	1.83±0.55^{a}
Soil + SMW (20 t/ha)	113.00±9.89^{b}	2.50±0.14^{abc}	7.00±1.41^{ab}	58.00±2.83^{a}	20.00±2.83^{ab}	2.19±0.11^{a}
Soil + SMW + EC (40 t/ha)	166.50±12.02^{c}	2.49±0.21^{ab}	12.00±1.41^{abc}	46.50±36.06^{a}	84.00±11.31^{d}	31.50±6.36^{a}
Soil + SMW + PM (40 t/ha)	173.50±9.19^{c}	2.61±0.15^{abcd}	24.00±4.24^{f}	84.00±11.31^{ab}	31.50±6.36^{bc}	2.34±0.11^{b}
Total	143.06±47.65	2. 63±0.21	12.89±6.19	78.00±24.74	33.00±19.80	5.44±9.62

Means with the same superscript are similar for the various treatments.

the quality of maize crop also increased as a result of the increasing compost application (Table 4). The values for leaf length per plant in each treatment were 81.00 ± 4.24 cm, 108.50 ± 17.67 cm and 101.50 ± 7.78 cm for 0, 9000 and 18000 t/ha of composted manure application, respectively. Similar observation was recorded for stem length, where the values revealed 72.00 ± 8.49 cm for no manure application (control), 207.0 ± 5.66 cm and 189.50 ± 12.02 cm for 9000 and 18000 t/ha of composted manure application, respectively. However, the effect of nutrient application on chlorophyll content was slightly significant ($p < 0.05$) as observed in the other parameters. Other nutrient combinations showed improved yields in most cases amongst the parameters, especially soil + SMW + PW at 40 t/ha application recorded significant differences ($p < 0.05$) across stem length, stem girth, number of leaves, leaf length, width and chlorophyll content.

Microbial analysis

Results indicate that the predominant micro-organisms associated with the biodegradation of the samples on application were identified as *Bacillus subtilis, Proteus vulgaris, Pseudomonas, Corynebacterium and Enterobacter* species. Enumeration of total microorganisms in the samples show that poultry droppings/manure had 5.3×10^5 cfu/g; spent mushroom waste 4.6×10^5 cfu/g; earthworm cast 4.0×10^5 cfu/g and; soil samples 2.8×10^5 cfu/g. These are displayed in Table 5.

DISCUSSION

Soil physical properties

Application of composted organic manures on

Table 5. Biochemical characteristics of isolates from the organic waste samples.

Colonial and cell morphology	Gram r x n	Motility	Indole	Urea	Oxidase	Catalase	Coagulase	MR	VP	Glucose	Lactose	Sucrose	Maltose	Probable identity
Large, gray or milky white or creamy moist colonies, straight rods in chains	+	+	-	-	-	-	+	-	-	AG	AG	AG	AG	*Bacillus subtilis*
Large mucoid colonies, straight rods in chains	-	+	-	-	-	-	-	-	-	AG	AG	AG	A	*Enterobacter* sp
Colonies have cremated edges, roundish about 6cm in diameter.	-	+	+	+	-	+	-	+	+	A	A	G	G	*Proteus vulgaris*
Irregular colonies, non – sporing, straight or slightly curved, slender rods, sometimes clubbed ends, cells arranged singly or in pairs.	+	-	-	-	+	+	-	-	-	AG	G	AG	AG	*Corynebacterium* sp
Large, flat milky colonies, rods are slightly curved but occur in pairs, occasionally in chains.	-	+	-	+	+	+	+	-	-	A	-	-	A	*Pseudomonas* sp

-, Negative; + positive; A = acid; G = gas; AG = acid and gas.

soils for the cultivation of maize in this study improved moisture content, possibly due to the colloidal and hydrophobic nature of the organic wastes. This finding supports the work of other scientists, who reported that the use of organic matter can improve soil health and crop yield on sustainable basis (Mbah et al., 2004; Mbah and Mbagwu, 2006). Similarly, enhancement of soil water retention capacity due to the manure, according to the study of Adeleye et al. (2010) could be probably due to structural improvement, which is increase in total porosity and the fraction of porosity involved in soil water storage. It is further believed that improvement in total porosity might be as a result of the improved soil aggregation, brought about by the improved soil organic matter content of the plots amended with the composts.

Plots amended with compost manure had similar soil temperature compared with plots with-out manure (0 t/ha control) application. This could be related to the improved soil organic matter content of plots amended with the organic wastes, which might have enhanced water retention capacity of the soil and consequently reduced soil tem-perature. Because the experiment was conducted in an open space, heat is dissipated to the atmosphere; also runoff water arising from frequent rainfalls drained into the silo/compost, which could reduce the temperature because of the retention of water by the organic materials. The process was controlled by regular mixing of water to a certain field capacity which moistened the compost and helped to moderate temperature (Ano and Agwu, 2006; Zahir et al., 2007a).

Organic matter is known to improve soil physical properties (Adesodun et al., 2005; Aluko and Oyeleke, 2005). On the other hand, addition of compost manure increased the soil bulk density. This observation is in agreement with the reports of Mbah et al. (2004) and Adeleye et al. (2010) who stated that application of organic manures improve and ameliorate several soil physical properties, such as bulk density, total porosity, penetration resistance and cohesion force.

Soil chemical properties

It was observed that the organic wastes com-posted and applied to the fields planted with maize crop gave a better performance.

It is highly likely that the continuous use of organic materials in the field may result in improving the organic matter status of soil, and thus can improve soil health and crop yields on sustainable basis. This is further supported by the slower mineralization rates of composted organic wastes than raw organic wastes added to soil (Zahir et al., 2007a). Zahir et al. (2007b) and Adeleye et al. (2010) in their separate study also reported that the residual effect of nitrogen and phosphorous based compost application on corn grain yield and nitrogen uptake lasted for one year, and had good performance effect on soil properties. Increase in growth and yield could also be attributed to enhanced nutrient use efficiency and physiological response of the maize crop to added organic wastes manure, which served as a source of macro and micro nutrients. Moreover, total nitrogen and phosphorous contents in the maize plants increased significantly in response to application of compost manure at 18000 t/ha.

Previous studies have also shown that composted organic materials enhanced fertilizer use efficiency, by releasing nutrients slowly and thus reducing the losses, particularly nitrogen (Paul and Clark, 1996; Muneshwar et al., 2001; Nevens and Reheul, 2003; Golabi et al., 2004; Felipo et al., 2004; Ahmad et al., 2006; Amujoyegbe et al., 2007; Polat et al., 2009; Ewuzie, 2009; Adeleye et al., 2010; Bamaiyi et al., 2011; Mbah et al., 2011).

Since addition of organic fertilizer increases mobilization of phosphorus (Table 3) and microbial activities in soil, it might also be a contributing factor in improving nutrition, as well as root system (Bahl and Torr, 2002; Salako, 2008). Similar studies by other workers have shown that the composted organic materials enhanced fertilizer use efficiency by releasing it slowly and thus, reducing its losses (Muneshwar et al., 2001; Nevens and Reheul, 2003; Asghar et al., 2006; Zahir et al., 2007a, b).

Plant performance

Organic wastes compost improved leaf nutrient concentration significantly. Cumulative effect of the organic wastes application was observed in the leaf nutrient concentration at 18000 t/ha treatment. This observation is in agreement with the reports of Adenawoola and Adejoro (2005) and Adeleye et al. (2010) that the cumulative agronomic value of some organic manure applied to agriculture soils could be five times greater and more beneficial than in the application of inorganic fertilizers. Bamire and Amujoyegbe (2005) and Nottidge et al. (2005) revealed that apart from high cost and scarcity of inorganic fertilizers, it destroys the soil physio-chemical properties, causing nutrient imbalance. Therefore, the use of organic manures for soil amendments to sustain adequate crop yields has been found to be more effective. Considering the effects of the nutrient sources on the chlorophyll content, there were significant impacts of the nutrient sources on the chlorophyll and this is usually evident in the dark green colouration of the maize leave and stem, indicating significant impact of the nutrient source; on the chlorophyll content of the maize plant, also indicating an improvement in the process of photosynthesis, and increased development and yield of the maize plant. The result also shows that the high quality of total chlorophyll observed in the maize corresponded to an increase in organic wastes application.

The effect of nutrient source on chlorophyll content, plant height, leaf area and grain yield was highly significant ($P < 0.05$). This result is in line with the assertion of Wormer et al. (2001) and Amujoyegbe et al. (2007) that plant genotypes differ in their responses to changing soil fertility and environmental conditions.

Microbial analysis

Poultry manures and spent mushroom wastes are nitrogen rich materials and are of economic importance as organic fertilizers, feed supplements or as energy sources (Polat et al., 2009; Bamaiyi et al., 2011). In addition to the nutritional contributions to the soil for plant production, they contribute diverse species of micro organisms, which enhance natural biogeochemical processes (Obire and Akinde, 2005; Adegunloye et al., 2007). *Bacillus subtilis, Proteus vulgaris, Pseudomonas, Corynebacterium* and *Enterobacter* species occurred as predominant bacterial isolates from the samples used as organic wastes materials. The presence of these microbes in the organic wastes by implication, shows that they posses more utilizable nutrients and hence increases mobilization of phosphorous, and therefore contribute to improving plant nutrition and metabolism (Ahmad et al; 2006) and also supported the mineralization rates of the organic wastes (prepared from the composted organic matter) that is made available to the soil. However, the earthworm forming casts are involved in decomposing litter and incorporating plant residues in soil horizons and therefore are known to enhance plant yield (Curry and Boyle, 1987) because of their beneficial effects in soil properties (Edwards and Bohlen, 1996; Bisht et al., 2006).

Conclusion

Composting is a cost effective and environmental friendly way of waste recycling (Hoitink and Fahy, 1986; Milner et al., 1998). It is a process in which organic waste materials are biologically converted into amorphous and stable humus like substances (under conditions of optimum temperature, moisture and aeration) that can be handled, stored and applied without any hazardous environmental impacts.

The novelty of the approach being used in this study is the application of organic fertilizer, thus saving N fertilizer and increasing crop yield, by applying raw and composted organic material in tons ha^{-1}. The technology is therefore: Cost effective as it reduces dependence on chemical fertilizer; helps in nutrients and water conservation; moreover, it is an economical and safe way of the disposal of organic wastes generated in urban/ metropolitan centers, so the reduction of huge piling of organic wastes in cities by this technology is an extra benefit.

Also, the use of value added organic fertilizer to get higher yield is therefore wise than sole application of either huge amount, low quality, raw organic material or adequate amount of chemical fertilizer. The use of organic manure ensures stability of soil structure improve soil organic matter status, nutrients availability and high crop yield

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