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Full Length Research Paper

Effect of compost and earthworm production on soil properties, growth and dry matter yield of maize in crude oil degraded soil

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The effect of compost and earthworm production on soil properties, growth and dry-matter yield of maize in crude oil degraded soil was studied. The treatment consisted of 250 g crude oil degraded soil (DS) and 50 g each of four different compost materials mixed differently with 250 g of degraded soil, and the compost were cassava peels (CP), cassava peels + poultry manure (PC), cassava peels + pig manure (GC) and cassava peels + pig manure + poultry manure (PGC) and 10 pieces of sub-adult earthworms (*Eudrilus eugenae*) were inoculated to each of the experimental pot after 11 days. The five treatments were replicated four times, data generated were subjected to analysis of variance test and treatment means were separated using least significant difference (LSD0.05). The results of the study indicated significant differences between the treatments in soil and agronomic parameters assessed. The application of compost and earthworm activities increased the plant height, leaf area, and number of leaves at 4 weeks after planting (WAP) and 6 WAP, and dry matter yield of maize. The shoot and root dry matter yield was observed to increase in the order PC > PGC > GC > CP > DS. Earthworm production in this study measured by the number survived and biomass weight showed CP and GC as the best culture for earthworm production in oil degraded soil. The degraded soil (DS) did not record any earthworm survival at harvest. The result of the soil analysis indicated less change in the textural class of the soil, and all the chemical parameters tested were enhanced by the compost and earthworm activities. Based on the results of growth rate and yield components of maize as well as soil chemical properties, the PC and PGC cultures having performed competitively better than the other treatments can be considered useful and adequate with the help of earthworm in reclaiming an oil degraded soil for crop production in a tropical environment like Nigeria.

Key words: Compost, earthworm, maize, crude oil, soil properties

INTRODUCTION

Land is an essential part of earth crust which contains soil, rocks, minerals, water and natural vegetation. Land is in various shapes and forms, home for structures and mining activities. While soil is parts of land that man cultivate for the purpose of planting his crops and it is often the fine earth less than 2 mm in diameter.

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Agricultural activities take place on land. So land is an important resource on which man depend for his livelihood as well as an important asset or legacy that he can bequeath to next generations. Therefore the way and manner man handles his environment with respect to land will determine to a greater extent his environmental comfort and healthiness and to lesser extent the life span of his next generation. For man live and derive his livelihood from the land. The advancement of science and technology, increase in urbanization and growth of human population has continuously accelerate the rates of consumption of mineral resource, the mining of this minerals either agricultural or non agricultural result to soil infertility, ecological imbalance and land degradation. Land degradation is the inability or non potentiality of the land to produce food, goods and services and maintain healthy ecosystem for over a long period of time. Soil is a living entity, with complex mixture of organic and inorganic materials that have been synthesized naturally through various actions and reactions, is a natural medium for plant growth as it provides crops with mineral nutrients and water, support, is an important reserve of water and mineral nutrients needed for crop production. So, a soil is degraded when it loses its capability to sustain crop production and other goods and services. Mbagwu (2003) asserted that soil degradation is the temporary or permanent lowering of the productive capacity of soil caused by over grazing, deforestation, inappropriate agricultural practices, over exploitation of fuel wood leading to desertification and other man-induced activities, such as: mining and oil drilling and refining, discharge of wastes and sludge, river diversion etc. Some of these man- induced activities often happen in the crude oil producing states of Nigeria, otherwise called Niger-Delta (south-south, Nigeria).

Soil degradation in the oil producing areas like the Niger-Delta region of Nigeria is mainly caused by oil pollution, oil drilling and spill, gas flaring and refining which affects the soil fertility status reducing the productivity of the soils. Kundu and Ghose (1997) observed that mining activities disrupt the landscapes and soil components such as soil horizons and structure, soil microbe population and nutrient cycles which are important for healthy ecosystem and therefore results in the destruction of vegetation and soil profile. When crude oil spills on soil the condition of the soil becomes unsatisfactory for plants, because there is insufficient aeration due to a decrease in the air filled pore space (Degong, 1990; Kostreba, 1999; Ufot and Akande, 2005). It leads to alteration of the physical and chemical properties of the soil such as structure, hydraulic conductivity, exchangeable cations and pH (Ogboghodo et al., 2001). Odu (1981) reiterated that oil pollution has less effect on soil physical properties than in chemical properties. Soil degradation due to oil exploration is caused by gas flaring pipelines leakage, oil waste dump and oil spills, drilling and refining (Odu, 1980; Okere et al., 2001). In oil producing regions of Nigeria, substantial amount of crude oil is spilled annually. Therefore the remediation or reclamation of such oil degraded soils is a process of improving the quality of the soil through some measures of biotic function that will help to return the productivity for agricultural purposes rather than abandoning the area. Tremblay and Levy (1993) and Mba et al. (2001) emphasized on the use of organic manure in soil remediation.

Compost is an organic matter that has been decomposed and use as organic fertilizer and soil amendment. It improves the physical and chemical properties of soil as well as biological activities that help to liberate nutrients for growth plant and ameliorate the structure of soil. Compost encourages plant growth capacity and help to withstand or resist tensile forces through its fibrous material (Goldsmith et al., 2011). Soil organisms and earthworms are organisms that assist the nature in maintaining nutrient flow from one system to another as well as minimize environmental degradation. Earthworms are natural bioreactors that proliferate along with other micro-organisms and provide required conditions for the biodegradation of wastes (Munnoli et al., 2010). They re-design the physical, chemical and biological structure of the soil environment and deposit casts rich in mineral nutrients on soil surface (Ansari, 2011; Verma and Shweta, 2011; Agburu, 2012). The remediation or reclamation of crude oil degraded soil like in the oil producing regions of Nigeria, according to Lone et al. (2008) and Kavamura and Esposito (2010), requires the establishment of stable nutrient cycles from plant growth and microbial process. This present study, therefore attempts to evaluate the effectiveness of cassava peel compost and earthworm production in liberating chemical nutrients and amelioration of oil degraded soil for optimum crop production.

MATERIALS AND METHODS

The experiment was carried out at the Faculty of Agriculture, Chukwuemeka Odimegwu Ojukwu University, Igbariam Campus, Anambra State. The area is located within latitude 6° 14'N and longitude 6° 45'E and 122 m above sea level in south eastern, Nigeria. The annual rainfall of the area varies from 1800 mm to about 2500 mm, the temperature of the area vary from 21 to over 25° while relative humidity is from 60 to over 85%.

Soil sample collection

Soil samples were collected from 0-30 cm depth at Asa in Ukwa-east local government area of Abia State, Nigeria where there is oil spillage on a vast land, due to breakdown in oil pipeline and due to oil exploration activities that take in this area. Asa is a community located between latitude 4° 45'N and 5°N and between longitude 7° E and 7° 15'E. The type of vegetation of the area was rain forest, with a mean annual temperature between 26.5 and 27°C and daily relative humidity of 70-85%. The major crops produced by farmers in the area are cassava, maize, yam and vegetable crops. The farmers in this community have abandoned those vast areas of land

Table 1. Initial properties of the degraded soil before treatment application.

Parameter	Value
Sand	72.60%
Silt	2.40%
Clay	26%
Textural class	Sandy clay loam
pH_{H20}	5.05
Available P	20.10 $mgkg^{-1}$
Total N	0.098%
OC	0.65 gkg^{-1}
OM	1.11 gkg^{-1}
Ca	2.80 $Cmolkg^{-1}$
Mg	0.80 $Cmolkg^{-1}$
K	0.108 $Cmolkg^{-1}$
Na	0.078 $Cmolkg^{-1}$
EA	0.08 $Cmolkg^{-1}$
ECEC	3.87 $Cmolkg^{-1}$
BS	98%

being degraded by the oil spillage do to nothing grows on it. In fact when the soil samples were being collected there was an oil films on the soil. The soil is heavily degraded. Soil samples were collected from five different locations within the affected area. These soil samples were bulk together inside a fiber jute bag, tied up and transported to Chukwuemeka Odimegwu Ojukwu University where it was allowed for 8 months before used for the potted experiment. The 8 months allowed before the soil samples can be used again for further studies was to assess the impact of the crude oil on the dry state of the degraded soil haven noted its effect on the fresh state. This is because, the unpublished work (though presented in one of the Faculty Lecture series), where by the crude oil degraded soil when freshly collected filled with oil films, was used in a potted experiment and guinea grass compost was used as treatment, earthworm introduced to the potted experiment and maize was used as test crop, no sign of germination was observed on the degraded soil throughout the period of the experiment and earthworm (*Eudrilus eugenae*) did not survive for 24 h on both the degraded and treated soils, though the guinea grass compost improve the germination and growth on the treated soils, the crops looked unhealthy and very tiny in structure. The physical and chemical properties of the soil before treatment application are presented in Table 1.

Compost preparation, inoculation, allocation and experimental design

100 g of fresh cassava (*Manihot esculenta*) peels were air-dried for two weeks and then soaked in water for two weeks to ferment, in order to reduce the cyanide content and soften it for earthworm consumption. 50 g of poultry and pig manure each were moistened overnight. The fermented cassava peels and manures (poultry and pig manure) were composted in air tight polythene bags as follows; 100 g of cassava peels + 50 g poultry manure (PC); 100 g of cassava peels + 50 g pig manure (GC); 100 g of cassava peels alone (CP); 50 g of cassava peels + 25 g of poultry manure + 25 g of pig manure (PGC), the compost was harvested after 18 days and 50 g of each compost was then mixed thoroughly with 250 g of degraded soil. The treatments mixtures were as follows; PC, GC, PGC, CP, and DS (degraded soil without treatment). These treatments where replicated four times and then put into plastic pots of dimension 17 cm x 23 cm with perforations at the base, the perforations were closed with cotton wool to avoid excessive drainage. The experiment was laid out in an artificially prepared green house constructed with white tarpaulin and the experiment was properly blocked. This was to avoid external water inform of rainfall to interfere and to moderate the temperature. The degraded soil and the amendment mixtures were watered and left for 5 days before sowing of maize, the test crop. This was to give time for the transformation and further decomposition of the mixture. Ten (10) pieces of sub-adult earthworms (*E. eugenae*) sourced from costal area of River Niger, Onitsha Anambra state, Nigeria were introduced into each of the experimental pot after 11 days. Four seeds of maize orba super II sourced from Agricultural Development Programme (ADP) Awka, Anambra State were planted per pot and ten days after planting, supply was made for those that did not germinate. The choice of maize as test crop was based on the fact that it is one of the major crops grown by farmers in the oil degraded area. Secondly maize can be grown and studied in pot experiment. The treatment types were watered every other day at the rate of 25 ml per pot and monitored daily for maize germination, cast production activities of earthworm and compost degradation. The experiment lasted for 8 weeks.

Variables evaluated

The evaluated variable were: plant height, leaf area and number of leaves per plant were taken two weeks after planting and continued till the 6th week after planting (WAP). At the end of the 8th week the number of earthworms survived and their biomass was evaluated. The plants were carefully uprooted from the pots and the soil particles washed away. The roots were carefully cut-off from the shoot. Both the roots and shoots were oven dried for 24 hours for the dry matter yield. Soil samples were collected from respective pots and the variables analyzed were: pH using a digital pH meter with solid to liquid ratio of 1:2.5, exchangeable cation Ca^{2+} and Mg^{2+} were extracted with ammonium acetate by Perkin Elmer atomic absorption spectrophotometer (Tel and Rao, 1982), while Na^{+} and

Table 2. Effect of compost and earthworm production on the growth, shoot and root dry matter yield of maize in a degraded soil.

Treatment	Maize height (cm)			Number of leaves			Leaf area (cm^2)			Shoot dry matter yield (gkg^{-1})	Root dried matter yield (gkg^{-1})
	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP		
DS	6.68^a	9.81^b	13.03^c	3.25^b	4.50^b	6.38^b	21.51^c	34.68^b	43.78^c	0.43^c	0.03^b
CP	6.59^a	11.34^b	12.50^c	3.63^b	5.00^b	6.13^b	19.92^c	23.35^b	35.50^c	0.59^c	0.38^b
PC	7.90^a	24.83^a	48.19^a	3.13^b	7.38^a	10.13^a	19.50^c	150.0^a	292.94^a	77.87^a	19.09^a
GC	10.73^a	15.51^b	26.78^b	4.13^b	7.13^a	9.25^a	37.43^c	66.95^b	107.5^b	24.65^b	10.82^a
PGC	12.86^a	26.53^a	47.43^a	4.38^b	7.75^a	10.13^a	38.51^c	144.3^a	266.92^a	74.30^a	15.13^a
LSD 0.05	NS	6.64	10.28	NS	1.82	1.57	NS	66.13	56.90	18.24	11.37

DS= Degraded soil; CP=Cassava peel compost; PC= Cassava peel + poultry manure compost; GC= Pig manure + cassava peel compost; PGC= Poultry manure + Pig manure + cassava peel compost; LSD= Least significant difference; NS= Not- significant; WAP= Weeks after planting. Means on the same column with the same letter do not differ significantly ($P<0.05$).

Table 3. Effect of compost materials on the biomass (g/pot) and survival of earthworm (*Eudrilus eugenae*) in a degraded soil at harvest.

Treatment	Number of earthworm survived/pot	Earthworm biomass at harvest (g/pot)
DS	0.00	0.00
CP	14.75^b	6.00^a
PC	7.25^b	1.18^c
GC	36.50^a	3.50^b
PGC	8.00^b	1.48^c
LSD 0.05	11.33	2.35

DS= Degraded soil; CP=Cassava peel compost; PC= Cassava peel + poultry manure compost; GC= Pig manure + cassava peel compost; PGC= Poultry manure + Pig manure + cassava peel compost; LSD= Least significant difference; NS= Not- significant. Means on the same column with the same letter do not differ significantly ($P<0.05$).

K^+ were determined on flame photometer. Organic matter was determined by the method of Nelson and Sommers (1982) and total nitrogen was by a semi-micro Kjedahl procedure as described by Bremner and Mulvancy (1982). Available P was determined by Bray II method. Exchangeable acidity was determined by the titrimetric method of Mclean (1982), while the effective cation exchange capacity (ECEC) was determined by the summation method;

$$\text{ECEC} = \text{TEB} + \text{TEA} \quad (1)$$

Base saturation (BS %) was calculated using this formula;

$$\text{BS\%} = [\text{TEA} / \text{ECEC}] \times 100 \quad (2)$$

Statistical analysis

Data generated from the study was analyzed using analysis of variance (ANOVA) tested on randomized complete block design (RCBD) according to Steel and Torrie (1980) and treatment means were separated using least significant difference (LSD) at 5% probability level.

RESULTS

Daily examination of the experiment

The daily examination of the experimental cultures showed that maize seeds started to germinate on the treated soils four days after planting, but it took more than five days to record maize germination in the untreated soils. Within five days after earthworm introduction, cast which is one of the major evidence of earthworm activity in a habitable ecology or environment was observed in treated soils and more than 7 days later in untreated soils. Though germination and growth was observed in untreated (degraded) soil, the maize plant was very tiny and looking unhealthy and most of the plants do not survive to maturity and harvest. While the maize plants observed in treated soils looked healthy, robust and fresh. Secondly none of the earthworm introduced to the degraded soil (DS) survived to harvest and the cast found on the DS soils were very scanty and insignificant. The degradation of compost materials and earthworm activities were more on the PC and GC, followed by PGC treated soils as against CP and DS soils. Thus, this influenced the kind of results obtained from the study summarized in Tables 1 to 4.

Initial properties of the degraded soil

The properties of the studied soil presented in Table 1 show that the soil is a sandy clay loam soil, with low contents of organic matter (1.11%) and carbon (0.65%).

Table 4. Effect of compost and earthworm production on the soil chemical properties.

Treatment	pH of H_20	N (%)	OM (%)	BS (%)	P ($mgkg^{-1}$)	Ca^{2+} ($Cmolkg^{-1}$)	Mg^{2+} ($Cmolkg^{-1}$)	K^{+} ($Cmolkg^{-1}$)	Na^{+} ($Cmolkg^{-1}$)	EA ($Cmolkg^{-1}$)	ECEC ($Cmolkg^{-1}$)
DS	5.79^{d}	0.32^{a}	0.91^{e}	85^{b}	18.00^{b}	4.00^{bc}	1.63^{b}	0.07^{b}	0.10^{abc}	1.12^{a}	7.28^{a}
CP	6.76^{c}	0.28^{a}	2.02^{c}	95^{b}	15.50^{b}	4.80^{a}	1.60b	0.06^{bc}	0.06^{d}	0.32^{b}	6.84^{a}
PC	8.34^{a}	0.56^{a}	1.32^{d}	99^{b}	30.60^{a}	3.60^{bcd}	1.35^{c}	0.04^{d}	0.08^{abcd}	0.08^{d}	5.42^{b}
GC	7.02^{b}	0.24^{a}	2.72^{a}	98^{b}	12.40^{c}	4.20^{b}	2.00^{a}	0.12^{a}	0.09^{abc}	0.16^{c}	6.57^{a}
PGC	7.62^{b}	0.12^{a}	2.58^{b}	97^{b}	9.80^{c}	3.20^{d}	1.20^{d}	0.05^{cd}	0.11^{a}	0.16^{c}	4.70^{b}
LSD 0.05	0.74	NS	0.10	NS	2.68	0.52	0.08	0.02	0.03	0.07	0.99

DS= Degraded soil; CP=Cassava peel compost; PC= Cassava peel + poultry manure compost; GC= Pig manure + cassava peel compost; PGC= Poultry manure + Pig manure + cassava peel compost; LSD= Least significant difference; NS= Not- significant; ECEC = Effective cation exchange capacity; EA = Exchangeable acidity, OM= Organic matter, BS= Base saturation. Means on the same column with the same letter do not differ significantly ($P<0.05$).

The soil is acidic and contain low level of nutrient elements, except in P that have high available content (20.10 $mgkg^{-1}$) compared to other nutrient elements, the studied soil is considered to be poor in these essential plant nutrient elements, according to the ratings and pH range classification of Landon (1991). Therefore crude oil degradation is an added impediment to the soil as this will adversely affect the productivity of the soil.

Effect of compost and earthworm production on the growth and dry matter yield of maize

The growth parameters presented on Table 2, showed non-significant differences among the treatments applied in 2 weeks after planting (WAP), however the highest maize height, number of leaves and leaf area was recorded in PGC, and the next in rank was the GC. The 4 and 6 WAP results on the Table 2 showed remarkable significant ($P < 0.05$) differences among the treatments. The order of increase in maize height in 4 WAP and 6 WAP were PGC > PC > GC > CP > DS and PGC > PC > GC > DS > CP respectively. The value of maize height recorded in PGC and PC at 4 and 6 WAP were statistical similar, but significantly better than the other treatments. The number of leaves and leaf area in 4 and 6 WAP follow the trend of maize height results with the highest value obtained in PGC. The analysis of the results recorded in this trial revealed that PC and PGC were at par in all the growth parameters assessed in this study, but competitively and significantly ($P < 0.05$) performed better than the other treatments. The result of the shoot and root dried matter yield showed that PC and PGC performed much better than the other amendments. The highest value of shoot and root dried matter yield was obtained from PC treated pots. The DS performed very poorly followed by the CP when compared to the values obtained from the other treatments. The analysis of the result on Table 2 equally showed that the values of maize height, number of leaves and leaf area increased as the weeks after planting increased from 2 to 6 WAP.

Effect of compost materials and maize production on the biomass (g/pot) and number of earthworm (*Eudrilus eugenae*) survived in a degraded soil at harvest

The result presented in Table 3 indicated significant ($P < 0.05$) difference among the treatments. The zero (0) value recorded in DS pots showed that no earthworm survived to harvest in DS, which may suggest un-habitable medium for earthworm production. The highest number of earthworm survived was recorded in GC treated pots, though this does not translate to the recorded biomass (g/pot), as the earthworm harvested from the treated GC pot at harvest were mainly young and very little sub adult earthworms. In contrast to GC, the more of sub-adult and matured earthworms was observed in CP treated pots which translated to the kind of biomass result obtained from the CP pots. Nonetheless, the result obtained may have indicated that GC and CP maybe considered as the best medium for earthworm production under the crude oil degraded soil.

Effect of compost and earthworm production on the soil chemical properties

The result of soil chemical parameters presented on Table 4 showed that there was significant ($P < 0.05$) difference among the treatments except for the result obtained for nitrogen (N) and base saturation (BS). The highest value recorded for these two parameters (N and BS) was observed in PC treated pots. For N, the value obtained from DS was even found to be higher in rank to PC than the rest of other treatments. The order of increase in BS were PC > GC > PGC > CP > DS. The pH of the treatments measured in water, indicated that the pH of the degraded soil was much enhanced. The pH changed from acidic medium of DS through neutral to alkaline medium observed in PC treated pots. The organic matter (OM) content of the treated soils were very significantly ($P<0.05$) improved. The percentage

Table 5. Effect of compost and earthworm production on the texture of the soil.

Treatment	Sand %	Silt %	Clay%	Textural class
DS	70.60^{a}	1.40^{d}	28.00^{a}	Sandy Clay Loam SCL
CP	71.60^{a}	2.40^{c}	26.00^{b}	Sandy Clay loam SCL
PC	76.60^{a}	8.40^{b}	15.00^{d}	Loamy Sand LS
GC	70.60^{a}	8.40^{b}	21.00^{c}	Sandy Clay loam SCL
PGC	75.60^{a}	9.40^{a}	15.00^{d}	Sandy loam SL
LSD0.05	NS	0.67	1.35	

DS= Degraded soil; CP=Cassava peel compost; PC= Cassava peel + poultry manure compost; GC= Pig manure + cassava peel compost; PGC= Poultry manure + Pig manure + cassava peel compost; LSD= Least significant difference; NS= Not-significant. Means on the same column with the same letter do not differ significantly (P<0.05).

increase with respect to GC and PC were 66.54 and 31.06% respectively. The order of increase in OM content were GC > PGC > CP > PC > DS. The available P content of the treated soils was not enhanced except for PC pots, which showed rapid increase in the available P content. The P content obtained from DS and CP were statistically similar but better than the values obtain from PGC treated pots. The exchangeable Ca, Mg, K and Na vary significantly ($P < 0.05$) among the various amendments. The result showed that the compost and earthworm production did not much influence the values of the exchangeable parameters of the degraded soil. The exchangeable Ca only increased in CP and GC treated soils. The values obtained from PGC and PC was statistically similar and was not better than the degraded soil (DS).

The compost and earthworm production greatly enhanced the exchangeable Mg of GC treated pots, with respect to the rest of the other treatments which are not in any way better than the degraded soil. Similar to Mg, the exchangeable K of GC was improved by 41.67% by the application of compost and earthworm production. The rest of the other treatments were not enhanced. The exchangeable Na of PGC treated pots was increased in comparison to the values obtained from the other treated pots and the percentage improvement was 9.09%. The exchangeable acidity (EA) and effective cation exchange capacity (ECEC) values of the treatments were significant ($P < 0.05$). The EA and ECEC values of the degraded soil were higher than the values obtained from the other treatments. The other of decrease in EA and ECEC were PC < GC, PGC < CP < DS and PGC < PC < GC < CP < DS respectively. The percentage decrease in value of EA in PC relative to DS value was 1300%, while that of ECEC with regard to PGC value was 54.89%.

The result of the soil physical properties presented on Table 5 showed that application of compost and earthworm production influenced the physical parameter of the soil, more especially the silt content of the degraded soil. Hence the textural class of the soil was changed from sandy clay loam, through loamy sand to sandy loam, which has distinct characteristics on the nutrient content of the soils.

DISCUSSION

The result of this study indicated that cassava peel compost is capable of improving the productivity of crude oil degraded soil by improving the growth and yield components of maize as well as increasing the production of earthworm (*E. eugenae*). The germination and growth of maize, as well as very short lived activities of earthworm observed on the degraded soil, was due to 8 months allowed for the soil before it was used for the potted experiment. Therefore based on the unpublished work and present study experiences, leaving oil degraded soil for a while or soil removal alone can even be a good management strategy for an oil degraded land. For instance Amakiri and Onofegara (1983) and Rowell (2003) observed that crude oil degraded land appeared to recover or becomes useful for plant growth after years because of the ability of the soil to maintain an equilibrium in carbon nitrogen ratio. Secondary soil removal of crude oil degraded soil for the purpose of ameliorating the soil for agricultural purposes was an adopted technique in the Middle East as far back as early nineteenth century, according to Pinstrup and Lorch (2001) to reclaim an oil degraded environment. Kostreba (1991) in his own studies maintained that the soil removal should be followed with amendment with fertilizer and a mixture of compost manure and wood ships to improve water holding capacity and to provide micro organisms with sufficient carbon and nutrients. While Tremblay and Levy (1993) and Mbah et al. (2001) emphasized on the use of animal manure in soil remediation.

Effect of compost and earthworm production on the growth and yield components of maize

The significant differences observed in growth and yield parameters assessed in this study could be due to differences in the nutrient content of the compost applied and probable to preference in compost diet by the earthworm species (*E. eugenae*). The non-significant value observed in the 2WAP might be that the compost has not been decomposed enough to release nutrients that will influence the maize growth in 2WAP. The result of 4 to 6WAP of the growth parameters and yield component parameters indicated that there were more release of nutrients which reflected on the values obtained, showing that the compost and earthworm have stimulated the soil organisms to release phyto hormones that stimulate nutrient absorption and plant growth. Goldsmith et al. (2011) observed increases in plant growth parameters when they used compost as soil amendment. Paterson (2003) in his study noted that increases in plant growth, flowering and crop yields are as a result of earthworms activities in plant litter degradation, as they increase soil microbial population that produce plant growth hormones.

The high growth rate and yield observed can as well be due to the formation of humic substances resulted from the degradation of the compost materials by the earthworm; humic substances are noted to stimulate root respiration, formation and growth. Atiyeh et al. (2002), observed that the effect of humic substances result in increased efficiency of the plant rooting system, that in turn improves the upper growth of plants such as shoots, leaves, flowers and fruit yield, while Bahman et al. (2004), stated that application of compost provides nutrients and liming effects for the growing plant.

The shoot and root dry matter yield of maize result was a clear evidence of the impact of the compost and the earthworm on the maize yield. The compost materials PC and PGC were however found to yield better in root and shoot dry matter yield and even best in growth parameters compared to the other treatments. This probable might be due to faster degradation of the compost mixtures (PC and PGC) by the earthworm preferences relative to other composts materials used in this study. This resulted to more nutrient release in the condition and form that the maize plant can absorb them or might as well be due to that root exudates of maize have energized the activities of micro-organisms that invariable help to source and provide plant nutrients for the maize plants in treated pots, but more in PC and PGC treated pots as a result of good atmosphere created by the earthworm and compost. Lavelle and Martin (1992) showed that the interaction between earthworms and soil microbes increase the provision of plant nutrients and stimulate plant growth. Samaranayake and Wijekoon (2010) using soil mixtures in potted experiment observed that the growth rate, shoot dry matter yield of maize was increased by the introduction of earthworms.

The increase in growth and yield of maize observed in this study could as well be regard as the effect of combination of different interacting factors such as accumulations of earthworm casts rich in plant nutrients, compost degradation, soil aeration due to earthworm burrowing within the maize root zone of soil and many other factors as was reported by Fragoso et al. (1996). The productivity of maize depends on nutrients requirement particularly that of N, P and K (Arunkumar, 2007) and compost contribute more in building up the phosphorous status of the soil (Sawar et al., 2008) all of which believed to have contributed in the yield and growth result obtained from the treated pots especially for PC and PGC pots. The growth and yield result as well showed that the CP compost is not good compost for effective rehabilitation and reactivation of oil degraded soil and that cassava peels required the mixture of animal manure for effective utilization, nutrient release and reclamation of impaired soil for crop production.

The remarkable difference in the growth and yield values obtained from degraded soils and treated soils, showed the capability of the compost and earthworm production in bioremediation and rehabilitating of poorly degraded soil. Earthworms are ecosystem engineers that influence soil properties (Agburu, 2012) and help to turn wastes into resources and at the same time minimizes pollution (Edward, 1998). There cast have been reported to be more biologically active and richer in micro flora, growth promoting rhizobacteria than their surrounding indigested soils (Scheu, 1997; Parthasarathi et al., 2007; Sinha et al., 2010). They are major components that regulate nutrient cycling processes in many ecosystems (Edward and Bohlen, 1996).

With the activities of this organism, the physical, chemical and biological compositions of the soil tend to increase couple with the active degradation of the compost of which the effect was reflected in the nature of the results obtained. Ratty and Hutha (2004) found beneficial effect of earthworm on soil structural development, nutrient cycling and productivity when introduced to a reclaimed mining sites and peat. The result of maize growth and yield tend to prove that oil degraded soil can effectively be bio-remediated, rehabilitated and reclaimed for efficient crop production earlier than expected using the combination of compost and earthworm.

Effect of compost materials and maize production on the biomass and survival of *Eudrilus eugenae*

The result of this study showed that earthworm (*E. Eugenae*) can successfully thrive or cultured in an oil degraded soil when assisted or supplied with organic materials as a source of feed. The significant difference in the number of earthworm that survived to harvest and weight could be attributed to the preference in the compost diet by the earthworm. Toutain et al. (1982) reported that earthworm show a preference for particular parts of a plant, while Nweke (2013) in his own study observed that earthworm (*E. eugenea*) not only show preference to grass diet but also show preferences to grass with or without animal manure. Hence he found out that Bracharia grass produced more compost than Bracharia mixed with pig manure. This probable might be what resulted in the biomass value obtained in CP (Cassava peel compost without animal manure), where sub-adult and matured earthworms was harvested at maturity suggesting best medium for earthworm production as against young and very little sub-adults earthworms harvested in the other treatments. This is why the number of earthworm survived in GC did not translate to weight obtained because earthworm harvested at maturity in GC were mainly young ones and few sub-adult. The significant difference in number of earthworm that survived and their biomass can as well be due to interaction between maize root, microbial processes and earthworm. Healthy and intact roots release a wide variety of chemicals into the surrounding soil, a process termed exudation (Rovira, 1969), some of these chemicals exuded by the plant roots act as signaling molecules or toxic allele chemicals (Grayston et al., 1998; Bertin et al., 2003). So probable maize roots might have released these toxic allele chemicals which are harmful to the earthworm activities coupled with lethal effect of crude oil and these acting together invariable reduced their production in this study. Though earthworm performed better in CP it does not translate or influence much the growth and yield parameters of the maize plant, probable the nutrient released are not in the form and condition that the maize plant can absorb them, because the result of soil chemical parameters presented in Table 4 indicated that the soil treated with CP are rich in soil nutrients. The zero (O) recorded for number and biomass of earthworm in DS showed that no earthworm survived to harvest. Though there were earthworm activities in the degraded soil (DS), it did not last beyond 5 weeks, probable there maybe still some toxic hydrocarbon materials which by virtue of watering the experiment, might have become harmful to the earthworm, hence limitation in their productivity and eventual death. Though the earthworm did not survive in DS to harvest its effect in growth, yield and soil chemical properties visa vies the initial soil properties in Table 1 is remarkable, probable due to its cast that have enriched the DS soil, before their death. For all intents and purposes, it can be deduced that for culturing earthworm (*E. eugenae*) using cassava peel as source of diet in crude oil degraded soil, it may be good not to add animal manure.

Effect of compost and earthworm production on the soil chemical and physical properties

The result of the soil chemical properties showed that production of the earthworm and compost enriched the chemical properties of the degraded soil, with the exception of %N and percentage base saturation (%BS) all the parameters tested in this study were significantly difference at $P<0.05$. The pH results of the treated soils in comparison to the degraded soils (DS) showed a favorable pH level, because at pH range of 6-7 most plant nutrients are readily available for plant uptake, while pH above 7 reduces the chances of the plants to absorb trace elements such as Fe, Mn, B etc (White, 1979; Greenland, 1981; Muller and Donahue, 1992; Tisdale et al., 1993). This was observable in the increase in growth and yield of maize obtained from the treated pots compared to the degraded soil (DS). The degraded soil (DS), result probable might have indicated the solubility of some trace elements such as Mn, Cu, cobalt and Zn which are toxic to the productivity of crops, some micro-organism proliferation and earthworm activities as well as less NO_3^- production. Hence the nature of the results obtained and death of earthworms inoculated. The OM content of the treated soils where highly increased relative to the DS soils which might be as a result of compost application thus the significant effect on the nutrient value of the plants consumed that translated into the growth and yield observed in this trial. Organic matter content is the store house of plant chemical nutrients. The available P, N and pH where increased more especially in PC treated pots compared to the other treatments and was readily made available for the maize plants, for PC pots gave the highest value in most of the growth parameters and in shoot and root dry matter yield of the maize plant among the other treatments. This result could also be explained on the ability of earthworm to modify characters of organic materials and productivity of the resultant product in the soil mixture. The high content of available P observed in the DS soils could be that traces of P are released from Al^{3t}, while low content of P recorded in most of the other treatments can as well be attributed to phosphorous (P) fixation by sesquioxides usually observed in highly weathered humid tropical soil like the studied soil. Therefore, result obtained from DS soils do signify that though a soil may be fertile or rich in plant nutrient but may not promote crop growth and yield due to nutrients fixation, soil pathogens, nutrient toxicity, soil pH and environmental factors like oil spillage.

The exchangeable cations (Ca^{2+}; Mg^{2+}; K^+; Na^+) of the soil were influenced by the compost application and earthworm production, though the influence is more in exchangeable Ca and Mg. The data obtained from the study also showed that exchange complexes were occupied mainly by Ca and Mg. The content of K is below the range given by Dutta (2005) for good crop production. The high record of Ca and Mg is a good omen as many physiological and biochemical processes in plants are due to the presence of Ca and Mg such as flower senescence and flower abscission (Glenn et al., 1998), adjustment of ethylene responses in plants (Zhang et al., 2002), fruit ripening (Ferguson, 1984), etc where due to calcium (Ca). Magnesium (Mg) activates more enzymes than any other mineral nutrient, making a significant contribution to plant growth and development (Epstein and Bloom, 2004).

The exchangeable acidity (EA) of the treated soils where greatly influenced compared to the acidity level of the degraded soil (DS), this signifies detoxification, nutrient availability and higher crop performance observed in the treated soils. The level of acidity dictated in DS, showed the impact of crude oil degradation as it lowers the soil pH thereby causing acidity. At low pH phosphate combines with aluminum and iron to form compounds (Al_3P0_4, $FeP0_4$) that are not readily available to plants, most micro-nutrients toxic to the growth of plants becomes soluble and available at about soil pH 5.5 and nitrogen fixation activities will be low. These activities could have been the reflection of the values obtained in DS soils in all the parameters tested in this study. The effective cation exchange capacity (ECEC) is the sum total of exchangeable bases (Ca^{2+}; Mg^{2+}; k^+; Na^+) plus the exchangeable acidity (EA, that is, H^+ + Al^{3+}), for soils in the humid tropical areas like the studied soil that are strongly weathered and are predominantly of variable charges and such variable colloid include Fe and Al-oxides, the ECEC measured give the more realistic CEC values which represents the potential fertility of the soil studied. The ECEC values obtained could be attributed to cations level especially Ca and Mg levels in the soils.

The soil physical properties were influenced especially the silt and the clay content of the soil. Odu (1980) reported that oil degradation has less effect on soil physical properties and that the texture of the soil degraded by oil has less significant changes. While SPDC (1998) argued that the structure of crude oil degraded soil may be weakened initially, but later improved when the hydrocarbons are incorporated by bacteria.

Conclusion

The result of the present study clearly showed that earthworm can be cultured in an oil degraded soil with organic materials as diet, the growth rate, shoot and root dry matter yield of maize as well as the soil parameters tested were greatly influenced by the compost and earthworm production. This signifies that an oil degraded soil can be reclaimed faster with the combination of earthworm and compost. From the data generated in this study, it is suggested that oil producing communities, where crude oil degradation due to oil drilling and oil spillage, gas flaring are paramount should imbibe the use of organic materials in combination with earthworm to reduce to the barest minimum scarcity of food, land abandonment, high cost of agricultural products, migration to urban centers, unemployment and improve generally environmental health of the community.

Conflict of Interests

The author has not declared any conflict of interest.

REFERENCES

Agburu EO (2012). The effect of earthworm on properties of soils of the district around Ugbokolo, Benue State, Nigeria. Integr. J. Environ. Sci. Technol. 35(2005):2980-2987.

Amakiri JO, Onofegara FA (1983). Effect of crude oil polluted on the growth of maize, okra, and pepper. Petrochem. J. 2(4):199-205.

Ansari AA (2011). Worms powered environmental biotechnology in organic waste management Int. J. Soil Sci. 6:25-30

Arunkumar A (2007). Effect of different levels of NPLC on growth and yield parameter of sweet corn Karnaka J. Agric. Sci. 20(1):41-43.

Atiyeh R, Lee S, Edwards C, Arancon Q, Metzger J (2002). The influence of humic acids derived from earthworm processed organic wastes on plant growth. Bioresour. Technol. 84(1):7-14.

Bahman E, Daniel G, John EG (2004). Residual effects of manure and compost application on corn production and soil properties, Agron. J. 96:442-447.

Bertin Yang X, Waston LA (2003). The role of root exudates and allele chemicals in the rhizophere. Plant Soil 256:67-83.

Bremner JM, Mulvancy CS (1982). Nitrogen total: In method of soil analysis part 2, American Society of Agronomy, Madison, WI. pp. 595-624.

Degong E (1990). The effect of crude oil spill on cereals, Environ. Pollut. 22:187-196.

Dutta AC (2005). Botany for degree students, Oxford, New Delhi. pp. 220-233.

Edward CA (1998). The use of earthworm in the break down and management of organic wastes: In Earthworm ecology, CA Edwards (ed), CRC, Press Boco Roton, FL pp. 327-254.

Edward CA, Bohlen PJ (1996). Biology and Ecology of Earthworms, 3rd edn Chapman and Hall, London. 426p

Epstein E, Bloom AJ (2004). Mineral nutrition of plants, principles and perspectives 2nd edn Sinauer associates Sunderland MA ISBN 0-87893-472-4.

Fragoso C, Brown GG, Patron JC, Blanchard F, Lavella P, Pashanasi B, Kuma TC (1996). Agricultural intensification, soil biodiversity in tropics: The role of earthworms. Appl. Soil Ecol. 6:17-35.

Ferguson B (1984). Calcium in plant senescence and fruit ripening. Plant Cell Environ. 7:477-489.

Glenn GM, Read ASN, Poovaiah BW (1988). Effect of calcium on cell structure, protein phosphorylation and protein profiles in senescing apples. Plant Cell Physiol. 29:565-572.

Goldsmith W, Silva M, Fischenich C (2011). Determining optimal degree of soil compaction for balancing mechanical stability and plant growth capacity. ERDCTN- EMRRP-SR 26.

Grayston SJ, Wang S, Campell CD, Edward AC (1998). Selective influence of plant species on microbial diversity in the rhizosphere soil, Biol. Biochem. 30:369-378.

Greenland DJ (1981). Characterization of soils. Oxford University Press, NewYork. 5p.

Kavamura VN, Esposite E (2010). Biotechnology strategies applied to the decontamination of soil polluted with heavy metals. Adv. Biotechnol. 28:61-69.

Kostreba L (1999). The remediation technique of crude oil polluted soil using organic materials for crop production: In proceedings of oil spill conference, American Petroleum Institute Washington DC. pp. 40-41.

Kundu NK, Ghose MK (1997). Soil profile characteristics in Rajmahal coalfield area. Indian J Soil Water Conserv. 25(2):110-113.

Lavelle P, Martin (1992). Small scale and large scale effects of endogeic earthworms on soil organic matter dynamics in soils of the humid tropics. Soil Biol. Biochem. 24(12):1491-1498.

Lone MI, He Z, Stoffela PJ, Yang X (2008). Phyto-remediation of heavy metal polluted soils and water progress and perspectives. J. Zhejiang Univ Sci. B. 9:210-220.

Mbah CN, Ezeugwu G, Anikwe MAN (2001). Effect of poultry droppings on soil physical properties and heavy metals uptake by maize plant. J. Agric. Food Technol. Environ. 1(1):119-122.

Mbagwu JSC (2003). Aggregate stability and soil degradation in tropics, paper presented at 2003 College of Soil Physics, ICTP Trieste Italy.

Mclean EO (1982). Soil pH determination: In Pase DL (ed). Methods of soil analysis part 2, Chemical Analysis Agronomy Series, No. 9, ASA, SSA, Madison WI, USA.

Muller WR, Donahue RL (1992). Soils: An Introduction to soils and plant growth, Prentice Hall India, New Delhi-11001. pp. 226-420.

Munnoli PM, Jaime A Teixeira da silva, Saroj Bhosle (2010). Dynamics of the soil – earthworm-plant relationship. A review. Dynam. Soil Dynam. Plant 4(1):1-21.

Nelson DW, Sommers LE (1982). Total organic carbon and organic matter: In Page CA, Miller RH, Keeny DR (eds). Method of Soil Analysis part 2, 2nd edn. Agronomy Monograph No. 9, ASA and SSSA, Madison, WI. pp. 539-579.

Nweke IA (2013). Plant nutrient release composition in vermicompost as influenced by *Eudrilus eugenae* using different organic diets. J. Ecol. Natur. Environ. 5(11):346-351.

Odu CTI (1980). Degradation and weathering of crude oil under tropical conditions: In proceedings of a seminar on the petroleum industry. Nig. Environ. V1:143-152

Odu CTI (1981). Petroleum industry and Nigeria Environment: In proceedings of a seminar on the petroleum industry and Nigeria environment held in Port Harcourt, River State, 1986.

Ogboghodo AE, Osemwota IO, Choker JU (2001). An assessment of the effect of crude oil pollution on soil properties, germination and growth of Maize (*Zea mays* L.) Two crude oil types Forcados light (UQCC) and Escravos light (Chevron): In Proceedings of Annual Conference, SSSN, held at University of Calabar, Nigeria, March, 2001. pp. 299-300.

Okere JU, Akamigbo FOR, Ufot UO (2001). The effect of local mining on soils around Enugu, Nigeria, 27th annual Conference of Soil Science Society of Nigeria (SSSN). pp. 291-299.

Parthasarathi K, Ranganthan LS, Anandi V, Zeyer J (2007). Diversity of micro flora in the gut, and casts of tropical composting earthworms reared on different substrates. J. Environ. Bal. 28:87-97.

Paterson E (2003). Importance of rhizodeposition in the coupling of plant and microbial productivity. Eur. J. Soil Sci. 54(4):741-750.

Pinstrup AP, Lorch FP (2001). Prospective on overcoming hunger, poverty and environmental degradation International Food Policy Research Institute, Washington DC. pp. 310-315.

Ratty M, Hutha V (2004). Earthworm communities in birch stand with different origin in central Finland. Pedobiologia 48(1):283-291.

Rovira AD (1969). Plant root exudates. Bot. Rev. 35(1):35-57.

Rowell MJ (2003). The effect of crude oil spills on soils in the reclamation of agricultural soil after oil spills. University of Alberta Press, Edmonton. pp. 32-33.

Samarayake JWK, Wijekoon S (2010). Effect of selected earthworms on soil fertility, plant growth and vermicomposting. Trop. Agric. Res. Extens. 13(2):33-40.

Sawar G, Hussain N, Schmeisky H, Muhammad S, Ibrahim M, Safdar E (2008). Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. Pak. J. Bot. 40:275-282.

Scheu S (1997). Microbial activity and nutrient dynamics in earthworm cast (Lumbricidae). Biol. Fertile Soils 50:230-234.

Sinha RK, Aganwai S, Chauhan K, Valani D (2010). The wonders of earthworms and its vermicompost in farm production: Charles Darwin’s friends of farmers’ with potentials to replace destructive chemical fertilizers from agriculture. Agric. Sci. 1:76-94.

Shell Petroleum Development Company (1998). Environmental devastation, SPDC Publishers, Warri, Nigeria.

Steel RG, Torrie JH (1980). Procedure of statistics. A biometrical Approach 2nd edn. McGraw-Hall, New York. pp. 633-690.

Tel DA, Rao R (1982). Automated and semi-automated method for soil plant analysis, Manual Series No.7, IITA, Ibadan.

Tisdale SL, Nelson WL, Beaton JD, Halin JL (1993). Soil fertility and fertilizers 5th edn Prentice Hall Inc. Upper Saddle River, New Jersey 07458, USA. pp. 45-561.

Toutain F, Villemin G, Albrecht A (1982). Ultra structural study of biodegradation processes, 11 Enchytraeids-leaf litter models. Pedobiologia 23:145-156.

Tremblay LK, Levy EM (1993). Bioremediation application of slow release fertilizer on low energy share lines: In Proceedings of oil spill conference, American petroleum Institute, Wessington, D. C. pp. 499-500.

Ufot UO, Akande O (2005). Soil survey of Mkpat Enin FADAMA soils, Akwa Ibom State of Nigeria for food productions: In proceedings of the 30th Annual Conference of the SSSN, University of Agriculture Makurdi, Nigeria. pp. 18-20.

Verma D, Shweta (2011). Earthworm resources of western Himalayan region. Indian Int. J. Soil Sci. 6:124-133.

White RE (1979). Introduction to the principles and practices of soil science, Blackwell Scientific publication, Oxford London p. 417.

Zang BG, Rouland C, Lattand G, Lavelle P (1993). Activities of digestive enzymes in gut of the tropical earthworm *Pontoscolex corethrus*. Eur. J. Soil Biol. 29(1):7-11.

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Influence of wood charcoal from Chlorophera excelsa on soil properties and yield components of maize

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Wood charcoals were mainly used for smoking of fish, meat and frying of corns and many times dump off as wastes in southeast, Nigeria. Their nutrient recycles and release when used as soil amendment has not been considered and evaluated by farmers in the southeast, Nigeria. This study was therefore carried out to assess the efficiency of wood charcoal technology in improving soil productivity. Influence of wood charcoal from *Chlorophera excelsa* on soil properties and yield components of maize were evaluated. Four different rates of wood charcoal (6, 4, 2 and 0 tha^{-1} that received no treatment application) were used. The treatments were laid out in randomised complete block design (RCBD) and treatment means were compared using least significant difference (LSD). The findings from the study showed non-significant ($P<0.05$) differences in most of the growth and yield components of maize tested. Significant differences were recorded in all the soil properties assessed except for percentage nitrogen (N). Higher values were observed in 4 tha^{-1} rates except for the values of pH, available phosphorus and percentage base saturation, where higher values were observed in 6 tha^{-1} rates of wood charcoal than the other rates of wood charcoal. The percentage increase in calcium content of the soil relative to the values obtained in 0 tha^{-1} rate was 13.04% (2 tha^{-1}), 11.76% (4 tha^{-1}) and 7.69% (6 tha^{-1}). While the percentage increase in the value of Mg^{2+} obtained in 4 tha^{-1} plots relative to control (0 tha^{-1}) plots was 28.5%. The data generated from both growth and yield component and soil properties showed that the values of parameters tested increased as the rate of wood charcoal applied increased, though this was not consistent in the growth and yield parameters and few cases in soil parameters. In comparison of the four different rates of the wood charcoal applied, 4 tha^{-1} rate seems to be an ideal than the other rates as it performed competitively better and were able to liberate plant nutrients more than the other rates of wood charcoal though these liberated nutrients were not reflected in most of the growth parameters assessed.

Key words*:* *Chlorophera excelsa* , crop growth, soil properties, wood charcoal.

INTRODUCTION

The availability of soil mineral nutrients in non-fixed and toxic form is natural requirement for crop growth. Crop plants require them for healthygrowth and good yield. Agricultural soils show mineral deficiency problems

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merely after short period of cultivation, especially in the south eastern soils of Nigeria. They are very fragile and delicate due to nature and prevailing environmental conditions. Hence,they suffer rapid decline in mineral nutrients after short cultivation and these are soils that tend to harbour crop production. The soils of this area are usually influenced by high rainfall and temperature coupled with the climatic change that have influenced greatly the periodic cycle of the rainfall with heavy downpour. This situation invariably causes low nutrient content and soil organic matter mineralisation.

Also with accelerated decrease in cation exchange capacity (CEC) resulting to increase in acidity of the soils. Hence, agricultural sustainability in the area faces a large constraint. Farmers, therefore, in their quest to improve their crop yield then sought to supply additional plant nutrients by application of organic or inorganic chemical fertilizers so that yield of crops will no longer be limited by the amount of plant nutrients that the natural system can supply. Thus, both the organic manure and chemical fertilizers are common forms of soil amendment that are routinely used in agricultural soils. Though their impact on soil mineral nutrients differ remarkably when they are surface applied or incorporated into the soil. Also because of the high rainfall observed in the study area, the efficiency of applied mineral fertilizers is very low.

In addition, many farmers in the study area cannot afford the cost of regular application of chemical fertilizers. Hence, nutrient deficiency is very prevalent in many crop production systems of the area. The application of organic wastes or manure in its own case have frequently been shown to increase soil fertility, but have not fared better because, according to Tiessen et al. (1984), under tropical conditions organic matter is usually mineralised very rapidly and from the work of Fearnside (2000) only a small portion of the applied organic compounds will be stabilised in the soil in the long term but successively released to the atmosphere as carbon iv oxide (CO_2).

Therefore, under this circumstance, the use of more stable compounds such as carbonised materials or their extract becomes useful both in availability and cost for agricultural sustainability. The works by Glaser (1999) and Glaser et al. (2000), showed that carbonised materials from the incomplete combustion of organic material (charcoal, black C, pyrogenic C) are responsible for maintaining high levels of soil organic matter and available nutrients. The works of Radlein et al., (1996) equally showed that coal from geological deposit (coal) and from various specialised procedure were successfully used for soil amelioration as carbonised materials comprised a wide range of materials from partly charred materials to graphite and soot particles. Therefore, the objective of this study is to examine the influence of wood charcoal from C. excelsa (Iroko) on soil properties and yield components of maize.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria. The experimental site is located within latitude 06°14’N and longitude 06°45’E. The total annual mean rainfall ranges between 1800 and 2000 mm while the temperature range during the rainy season is between 21° and 24°C and an estimated relative humidity range of 64 to 90%.

Land preparation and treatment allocation

The experimental site was manually cleared and debris removed. The plots were then laid out in a randomised complete block design (RCBD) with four treatment materials and four replications to give 16 plots. The size of each plot measured 3 m × 4 m (12 m^2) with a distance of 1 m between the blocks and 0.5 m pathway between plots. The treatment consisted of the appropriate rate of wood charcoal made from *C. excelsa* (Iroko) which were applied to their respective plots. The treatment summaries are:

2 tha^{-1} wood charcoal equivalent to 2.4 kg/ha
4 tha^{-1} wood charcoal equivalent to 4.8 kg/ha
6 tha^{-1} wood charcoal equivalent to 7.2 kg/ha
0 tha^{-1} control (CO) that received no treatment

Each of these rates of wood charcoal were grounded and applied evenly on the plot and incorporated into the soil one week before sowing to allow mineralisation of nutrients in the treatment. Maize hybrid seeds (Oba super II) were planted two per hole at the spacing of 76 cm × 25 cm, which was done one week after the incorporation of the wood charcoal. The seedlings were thinned down to one plant per stand two weeks after germination, while empty stands were supplied. The experimental field was kept relatively weed free till harvest. Soil samples prior to treatment application was collected from different locations after field preparation and bulked together and analysed for the physical and chemical parameters of the soil (Table 1). At the end of the study, soil samples were collected from individual plots and used for the determination of physical and chemical parameters of the soil according to the procedure described by Black (1965). Five maize plants were randomly selected and used to measure plant height and leave area at 2, 4, 6 and 8 weeks after planting as well as length of cob/plant, numbers of cob/plant and cob’s diameter.

Data collected from the study was tested on analysis of variance based on randomised complete block design (RCBD) according to Steel and Torrie (1980), while least significant difference (LSD) at 5% was used to compare treatment means.

RESULTS

The initial soil properties of the study area in Table 1 showed that the soil is sandy with low contents of organic carbon (0.71%) and organic matter (1.23%) as well as low values in major plant nutrients tested. Hence, the soil of the experimental site was found to be deficient in the major plant nutrients.

The result of the growth parameter recorded in Table 3 showed that the rates of wood charcoal applied have no effect on the plant height and leaf area tested for 2 to 8 weeks after planting (WAP) except for plant height at 2 WAP. The plant height and leaf area result obtained equally showed that the plots that received different rates

Table 1. Physical and chemical properties of the studied soil prior to treatment application.

Parameter	Values
Coarse sand	46%
Fine sand	43%
Silt	7%
Clay	4%
Textural class	Sandy
pH H_2O	6.8
OC	0.71%
OM	1.23%
N	0.06%
Na^+	0.15 $cmolkg^{-1}$
K^+	0.19”
Ca^{2+}	0.13 ”
Mg^{2+}	2.00 ”
CEC	18.4 ”
BS	82.29 ”
Avail. P	5.60 $mgKg^{-1}$
H^+	0.80 $cmolkg^{-1}$

Table 2. Nutrient content of the wood charcoal used for the study.

Parameter	Value
pH H_2O	10.4
OC	10.47%
OM	18.06%
N	0.084%
Na^+	0.19 $cmolkg^{-1}$
K^+	0.21 $cmolkg^{-1}$
Ca^{2+}	0.06 $cmolkg^{-1}$
Mg^{2+}	0.10 $cmolkg^{-1}$
Avail. P	0.07 $mgkg^{-1}$

Table 3. Effect of wood charcoal on the growth and yield component.

Treatment (tha^{-1})	2WAP		4WAP		6WAP		8WAP		Length of cob/plant (cm)	Numbers of cob/plant	Cob's diameter (cm)
	PH (cm)	LA (cm^2)	PH (cm)	LA (cm^2)	PH (cm)	LA (cm^2)	PH (cm)	LA (cm^2)			
0	8.16	6.42	21.34	33.65	36.17	59.73	48.92	70.94	5.82	1.9	3.96
2	7.25	5.67	19.08	24.34	30.17	41.44	43.25	60.45	5.70	2.1	3.87
4	7.17	6.50	21.60	31.92	35.00	54.42	50.42	84.36	5.82	2.1	3.62
6	7.42	6.00	19.75	29.54	32.42	46.15	48.92	76.64	5.17	1.5	3.43
LSD0.05	0.04	NS	NS	NS	NS	NS	NS	NS	NS	0.33	NS

WAP = Weeks after planting; PH = Plant height; LA = Leaf area; LSD = Least significant difference; NS = Not – significant.

of wood charcoal did not perform better than the control plots except at 8WAP where the treated plots especially the 4tha^{-1} wood charcoal gave the highest plant height and leaf area followed by 6 tha^{-1} wood charcoal, but they

Table 4. Effect of wood charcoal on the chemical properties of the soil.

Treatment (t/ha)	pH H_2O	OM (%)	N (%)	P (mgkg^{-1})	BS (%)	CEC (cmolkg^{-1})	EA (cmolkg^{-1})	Na^{+} (cmolkg^{-1})	K^{+} (cmolkg^{-1})	Ca^{2+} (%)	Mg^{2+} (%)
0	6.20	0.94	0.04	3.73	75	18.40	0.80	0.121	0.147	12.0	2.0
2	6.40	1.08	0.07	3.73	77	18.40	0.60	0.133	0.164	13.8	0.4
4	6.50	1.14	0.08	4.66	78	19.20	0.80	0.146	0.182	13.6	2.8
6	6.60	1.08	0.08	8.39	87	19.20	0.80	0.133	0.173	13.0	1.4
LSD0.05	0.27	0.02	NS	0.08	1.29	0.11	0.14	0.014	0.013	0.97	1.49

Table 5. Effect of wood charcoal on the particle size of the soil.

Treatment (t/ha)	Coarse sand (%)	Fine sand (%)	Clay (%)	Silt (%)	Textural class
0	45	44	4	7	Sandy
2	46	43	4	7	Sandy
4	43	46	4	7	Sandy
6	40	51	4	5	Sandy
LSD0.05	0.62	0.40	NS	0.66	

were not significantly ($P<0.05$) different. The result of the length of cob/plant and cob's diameter showed non-significant ($P<0.05$) difference among the treatments. While number of cob/plant show significant difference among the treatments, with the values obtained from 2 and 4 tha^{-1} being statistically similar, but significantly ($P<0.05$) better than the 6 tha^{-1} plots. Critical observation of the data obtained for the growth parameters showed that the plots treated with 4 tha^{-1} wood charcoal performed better than the other treatments. Though its effectiveness were minimally observed in plant height at 2 and 4 WAP and leaf area at 4 and 6 WAP as well as cob's diameter.

The values obtained for soil chemical properties recorded in Table 4 indicated that the wood charcoal from the *C. excelsa* influenced the chemical properties of the soil. All the parameters tested show significant ($P<0.05$) difference among the treatments with the exception of total nitrogen result.

The result of the soil pH showed that the soil pH increased gradually as the rates of wood charcoal application increased and the order of increase were 6 > 4 > 2 > 0 tha^{-1}. The highest organic matter (OM) content was observed in 4 tha^{-1} plots compared with the other treated plots and was significantly ($P<0.05$) different with the other treatments. The values obtained in 2 and 6 tha^{-1} treated plots were statistically similar but significantly ($P<0.05$) better than the values obtained in 0 tha^{-1} plots. The result of available P and base saturation (BS) showed that the plots treated with 6 tha^{-1} gave the highest value and were significantly ($P<0.05$) different from the other treatments. The next in rank is 4 tha^{-1} treated plots of which its available P value is significantly better than the 2 and 0 tha^{-1} results. The base saturation (BS) values indicated that as the rate of wood charcoal application increased the value of BS increased and the order were 6 > 4 > 2 > 0 tha^{-1}. The result of cation exchange capacity (CEC) and exchangeable acidity (EA) recorded in Table 4 showed significant difference among the treatments. The values of CEC indicated that 4 and 6 tha^{-1} values were statistically similar, but significantly better than the values obtained in 2 and 0 tha^{-1}, while values of EA showed that the values obtained in 0, 4 and 6 tha^{-1} are statistically similar, but significantly better than the values obtained in 2 tha^{-1} rates of wood charcoal applied.

The result of Na^{+} and K^{+} showed significant ($P<0.05$) difference among the treatments. The highest value in Na^{+} and K^{+} was observed in 4 tha^{-1} treated plots of which its Na^{+} value was significantly better than the other treatments. While its K^{+} value was statistically similar with 6 tha^{-1} value but significantly better than the value obtained in 0 and 2 tha^{-1}. The exchangeable Ca^{2+} and Mg^{2+} result in Table 4 were significant ($P<0.05$) and the order of increase for Ca^{2+} were 2 > 4 > 6 > 0 tha^{-1} while Mg^{2+} order of increase were 4 > 0 > 6 > 2 tha^{-1}.

The percentage increase in Ca^{2+} relative to the values obtained in 0tha^{-1} was 13.44% (2 tha^{-1}), 11.76% (4 tha^{-1}) and 7.69% (6 tha^{-1}). The percentage increase in the value of Mg^{2+} obtained in 4tha^{-1} relative to the value obtained in control plots were 28.57% while its percentage decrease relative to 2 tha^{-1} plots were 600%. The soil chemical parameter results showed that the wood charcoal applied at 4tha^{-1} performed competitively better and were able to liberate mineral nutrients better than the other rates of wood charcoal applied, though it is not true for soil pH, available P, BS and Ca^{2+} contents of the soil studied. Nonetheless, the release of these chemical nutrients was not adequately reflected in the growth and yield parameters of the tested crop.

The result of the particle size analysis of the soil in (Table 5) indicated significant differences in coarse and fine sand particles and silt content of the soil, but showed non-significant differences as well as non-change (as the values are the same) in the clay content of the soil. Thus, with regard to the clay content of the soil the influence of the different rates of wood charcoal are the same and equal. The influence of 0, 2 and 4 tha^{-1} rates of wood charcoal on the silt content of the soil were equal and statistically similar, but significantly better than silt content of 6 tha^{-1} rate of wood charcoal. The influence of wood charcoal on the sand particles showed that 6 tha^{-1} rates had more sand particles than the other rates. While the rates of 0, 2 and 4 tha^{-1} the same values of sand particles on the average were observed.

DISCUSSION

The soil analysis result in Table 1 showed that the studied soil is very deficient in major mineral nutrients; the values are below the fertility classification of Ibedu et al. (1988) and Landon (1991). Hence, the soil is deficient in plant nutrients. The nutrient content in wood charcoal (Table 2) applied indicated that the organic matter, organic carbon, pH and some other nutrients tested are higher relative to quantity of the nutrients available in the soil before treatment application.

The effect of wood charcoal on the growth and yield component of maize was observed to be non-significant. This problem may be attributed to the amount present in the individual rates applied and their slow release as well as non-synchronisation of nutrient released within the short period of growth of the maize plant. The differences in values of these parameters tested, however, may be as a result of differences in plant nutrient in the rate of treatments applied.

However, non-significant values in growth and yield component of crops have been reported in the works of Nweke and Nsoanya (2013a,b), Nweke and Obasi (2013) and Nweke et al. (2014) following organic waste application in soil, the post-harvest soil analysis result of this study show that wood charcoal from *C. excelsa* when used as soil amendment has the capacity of increasing the pH level thereby reducing the acidity levels of the soil required for crop production as was observed in Table 4. This increase in soil pH level is good omen for agricultural production as low pH value limits soil productivity, since it affects availability and uptake of nutrients by plants because at low pH, acid soils are normally flocculated (Haynes and Naidu 1998). The wood charcoal at rate of 4 tha^{-1} was observed to have being a good estimate of amount required significantly to improve soil properties and enhance growth and yield components of maize (Table 3).

Using cocoa pod ash and wood ash, by Ayeni et al. (2008) and Mbah et al., (2010) respectively, as soil amendment reported increased soil pH relative to non-ash treated soil. The OM and TN content of the treated plots were observed to be improved relative to the control plots. This improvement could be attributed to the higher level of OM and TN in wood charcoal applied than the soil. Organic matter according to Tisdale et al., (1993) and Brady and Weil (2006) play important roles in essential nutrient availability and soil improvement.

The influence of the wood charcoal on the soil available P, BS% and CEC values varied among the rates and appreciated relative to the control rate. The level of soil available P and other nutrients might have been influenced by the changes in soil pH due to application of wood charcoal since the availability of P and its solubility is pH dependent. In line with the findings of this study, Mbah et al. (2010) and Nweke and Nsoanya (2013b) reported significant increase in available P and plant nutrients in soils amended with wood ash and organic wastes respectively relative to control plots. Kayode and Agboola (1983) attributed the increased CEC in wood ash amended soil to increased cations Ca, K and Na as was observed in the present study. In support of the findings of this study, previous study like Ayeni et al. (2008), Adele et al. (2010), Nweke and Nsoanya (2013b) and Nweke et al. (2014) had shown that organic wastes increased soil OM, N, pH, P, CEC, exchangeable base and reduced soil exchangeable acidity (EA).

The post-harvest soil analysis showed that the rates of wood charcoal applied significantly influenced the particle size distribution but did not affect the textural class of the soil. There were more sand fraction which indicates good aeration and will not present problem with drainage and plant root penetration. There were no differences between the clay contents of the different rates of wood charcoal and the silt contents of 0, 2 and 4 tha^{-1} rates of wood charcoal. Nweke and Nsoanya (2012) observed no difference between the clay and silt content of soils of the same locality.

Conclusion

The findings from the study have shown that wood charcoal from *C. excelsa* is capable of improving soil properties and crop production. The values obtained from 4 and 6 tha^{-1} wood charcoal in most of the soil and plant parameters tested were statistically similar. This placed 4 tha^{-1} in this particular study as the optimum rate of wood charcoal application for soil fertility improvement and maize growth. The material is cheap, available and can be sourced by poor resource farmers and used for soil and crop improvement.

Conflict of interests

The authors have not declared any conflict of interests.

REFERENCES

Adeleye EO, Ayeni LS, Ojeniyi SO (2010). Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on Alfisol in southwestern Nigeria. J. American Science 6 (10):509-516.

Ayeni LS, Adetunji MT, Oyeniyi SO (2008). Comparative nutrient release from cocoa pod ash, poultry manure and NPK 20:20:20 fertilizer and their nutrient combination incubation study Nig. J. Soil Sci. 18:114-123.

Black CA (1965). Method of soil analysis II chemical and microbiological properties. Am. Soc. Agron. Madison, Wisconsin. 157 p.

Brady NC, Weil RR (2006). Nature and properties of soil, 13th edition London, Prentice Hall. pp. 595-624.

Fearnside PM (2000). Global warming and tropical land use change, green house gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation, Climatic Change. 46:115-155.

Glaser B (1999). Ergenschaften und stabilch des Humuskrpers der indianerschwar zerden Amazon iens Bayreuther Bodenkunliche Berichte. 68.

Glaser B, Haumaier L, Guggenberger G, Zeck W (2001). The terra preta phenomenon a model for sustainable agriculture in the humid tropics naturwissenschaften 88:37-41.

Glaser B, Balachov E, Haumaier L, Guggenberger G, Zech W (2000). Black carbon in density, fractions of anthropogenic soils of the Brazilian Amazon region. Org. Geochem. 31:669-678.

Haynes RJ, Naidu RC (1998). Influence of lime fertilizer and manure application on soil organic matter content and soil physical conditions, a Rev., Nutrient Cycling in Agrosys. 51:123-137.

Ibedu MA, Unambra RPA, Udealor A (1988). Soil management systems in relation to farming systems development in the southeastern agricultural zone of Nigeria. Paper presented at the National Farming System Research Workshop, Jos, Plateau State, Nigeria. pp. 26 -29.

Kayode GO, Agboola AA (1983). Investigation on the use of macro-and micro-nutrients to improve maize yield in South Western Nigeria. Fertilizer Research 4(3):211-221.

Landon JR (1991). Booker tropical soil manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics, Longman Scientific and Technical New York. P 33.

Mbah CN, Nwite JN, Njoku C, Nweke IA (2010). Response of maize (Zea *mays* L.) to different rates of wood ash application in acid ultisol in southeast Nigeria. Afr. J. Agric. Res. 5(7):580-583.

Nweke IA, Nsoanya LN (2012). Inventory of physico-chemical characteristics of soils of the Teaching and Research Farm, Faculty of Agriculture, Anambra State University, Igbariam Campus, Nigeria. In Proceedings of International Agricultural Conference 6th - 9th May, 2012, held at Anambra State University, Igbariam Campus, pp. 488-493.

Nweke IA, Nsoanya LN (2013a). Effect of Poultry Manure and Inorganic Fertiliser on the Performance of Maize (Zea Mays) and Selected Physical Properties of Soils of Igbarian Southeastern Nigeria. J. Agric. Rur. Dev. 16(1):1348-1353.

Nweke IA, Nsoanya LN (2013b) Effect of different rates of rice mill waste on soil chemical properties and grain yield of maize (Zea Mays). J. Agric. Rur. Dev. 16(1):1431-1436.

Nweke IA, Obasi MN (2013). Effect of different levels of pig manure on the growth and yield of okra (*Abelmoschus esculentus* Ush). In proceedings of the 47th annual conference of the Agricultural Society of Nigeria, Ibadan 2013. pp. 23-26.

Nweke IA, Okoli PSO, Enyioko CO (2014). Effect of different rates of poultry droppings and plant spacing on soil chemical properties and yield of cucumber. Elixir Agriculture 70(2014):23934-23940.

Radlein D, Piskorz JK, Maher P (1996). Method of producing slow-release nitrogenous organic fertilizer from biomass. European patent application 0716056AI.

. Steel GD, Torrie JN (1980). Principles and Procedures of Statistics. A Biometrical Approach 2nd ed. McGraw Hill Book Co., New York. P. 633Tiessen H, Stewart JWB, Cole CV (1984). Pathways of phosphorous transformation in soils of differing pedogenesis. Soil Sci. Soc. Am. J. 48:853-858.

Tisdale SL, Nelson WL, Beaton JD, Havlin A (1993). Soil Fertility and Fertilizers. 5th edn. Macmillan Publishing Company New York USA.

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