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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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ABSTRACT

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 250g crude oil degraded soil (DS) and 50g each of four different compost materials mixed differently with 250g 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 (LSD=0.05). 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 activities in the 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.

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 part of land that man cultivate for the purpose of planting his crops and it is often the fine earth less than 2mm in diameter. 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 his next generation. 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 a living entity with complex mixture of organic and inorganic materials that have been synthesized naturally through various actions and reactions, a natural medium for plant growth as it provides crops with mineral nutrients and water as well as support, is an important reserve for store of water and mineral nutrients needed for crop production. Hence a soil is said to be 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 man-induced activities could be; mining and oil drilling and refining, discharge of wastes and sludge, river diversion etc as it was obtainable in the Niger-Delta region of 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 thereby reducing the productivity of the affected soil. Kundu and Ghose (1997) observed that mining activities disrupt the athletics of the landscapes and disrupt 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 of insufficient aeration due to a decrease in the air filled pore space (Degong, 1990; Kostreba, 1999; Ufot and Akande, 2005). It

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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 than the chemical properties. Pollution 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) and as was reported by Edith (2003), crude oil pollution on soils can be rated as follows, 100ml/20kg soil - low; 300 ml/20kg soil-moderate and 500 ml/20kg soil- highly polluted. In Niger Delta region of Nigeria substantial amount of crude oil is spilled annually. Therefore the remediation or reclamation of such oil polluted 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 plant nutrients and ameliorate the soil. Soil organisms and earthworms are soil biological 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). The remediation or reclamation of crude oil degraded soil like in the Niger-Delta region of Nigeria, according to Lone et al., (2008); Kavamura and Esposito, (2010), requires the establishment of stable nutrient cycles from plant growth and microbial process. Thus it was against this back drop, that this study was conceptualize to evaluate the effect of compost and earthworm production on soil properties growth and maize dry matter yield in a crude oil degraded soil.

Materials and methods

The experiment was carried out in the Faculty of Agriculture, Chukwuemeka Odimegwu Ojukwu University, Igbariam Campus, Anambra State. The area is located within latitude 6^o 14'N and longitude 6^o 45'E and 122m above sea level in south eastern, Nigeria.

Soil sample collection

Soil samples were collected from 0-30cm 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 equally oil exploration activities due take place there. Asa is a community located between latitude 4^o 45'N and 5^oN and between longitude 7^o E and 7^o 15'E. The type of vegetation of the area was rain forest, with a mean annual temperature between 26.5^{oC} and 27^{oC} and daily relative humidity of 70-85%. The farmers in this community have abandoned those vast area of land being degraded by the oil spillage due to nothing thrives on it. In fact when the soil samples were being collected oil films are clearly being seen on the soil. The soil is heavily polluted. Soil samples were collected from five different locations within the polluted 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. Even before the soil samples could be used for the experiment hammer was used to break up the clods as the effect of the oil films dried up have bind up the soil together that it was very difficult to break-up by hand and tilth for experimental use for crop root penetration. The physical and chemical properties of the soil before treatment application are presented on Table 1.

Compost preparation, inoculation, allocation/experimental design

100g of fresh cassava peels were air-dried for two weeks and then soaked in water for two weeks to ferment. 50g 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;100g of cassava peels + 50g poultry droppings (PC); 100g of cassava peels +50g pig manure (GC); 100g of cassava peels alone (CP); 50g of cassava peels + 25g of poultry droppings + 25g of pig droppings (PGC), the compost was harvested after 18 days and 50g of each compost was then mixed thoroughly with 250g of degraded soil. 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 with perforation at the base, the perforations were plugged 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 (*Eudrilus 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 treatment types were watered every other day at the rate of 25ml per pot and the experiment lasted for 8 weeks.

Data collection

Data were collected for plant height, leaf area and number of leaves per plant were taken two weeks after planting and continued till the 6^{th} week after planting (WAP). At the end of the 8^{th} week 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 were analyzed for pH using a digital pH meter with solid to liquid ratio of 1:2.5. Exchangeable cation ca^{2t} and mg^{2t} were extracted with ammonium acetate by Perkin Elmer atomic absorption spectrophotometer (Tel and Rao, 1982), while Na^+ and 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;

$$ECEC = TEB + TEA \qquad (1)$$

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

$$BS\% = \frac{TEA}{ECEC} \times \frac{100}{1} \qquad (2)$$

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 applied 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 table 1-4.

Initial properties of the degraded soil

Table 1 show that the studied soil is of a sandy clay loam, with low contents of organic matter (1.11%) and carbon (0.65%) the soil is acidic and contain low level of major nutrient elements, though relatively rich in available P (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 increase from 2 to 6 WAP.

Effect of compost materials and maize production on the weight (gkg^{-1}) 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 weight (gkg^{-1}), as the earthworm harvested from the treated GC pot at harvest were mainly young's 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 weight 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 4a showed that there was significant (P=0.05) differences 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 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 of the treated soils was not enhanced except for PC pots, which showed rapid increase in the available P values. The P values 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 activities 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 at par and was not better than the degraded soil (DS).

The compost and earthworm activities 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 activities. 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 with regard to PC 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 4b showed that application of compost and earthworm activities 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 context of the soils.

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

Parameter	Value
Sand	72.60%
Silt	2.40%
Clay	26%
Textural class	Sandy clay loam
pH_{H20}	5.05
P	20.10mgkg^{-1}
N	0.098%
OC	0.65%
OM	1.11%
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%

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

	Maize height (cm)			Number of leaves			Leaf area (cm^2)			Shoot dry matter yield	Root dried matter yield
Treatment	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	gkg^{-1}	gkg^{-1}
DS	6.68	9.81	13.03	3.25	4.50	6.38	21.51	34.68	43.78	0.43	0.03
CP	6.59	11.34	12.50	3.63	5.00	6.13	19.92	23.35	35.50	0.59	0.38
PC	7.90	24.83	48.19	3.13	7.38	10.13	19.50	150.06	292.94	77.87	19.09
GC	10.73	15.51	26.78	4.13	7.13	9.25	37.43	66.95	107.59	24.65	10.82
PGC	12.86	26.53	47.43	4.38	7.75	10.13	38.51	144.32	266.92	74.30	15.13
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= Non- significant.

Table 3. Effect of compost materials and maize production on the weight (gkg^{-1}) and survival of earthworm (*Eudrilus eugenae*) in a degraded soil at harvest

Treatment	Number of earthworm survived/pot	Earthworm biomass at harvest gkg^{-1}
DS	0.00	0.00
CP	14.75	6.00
PC	7.25	1.18
GC	36.50	3.50
PGC	8.00	1.48
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= Non- significant.

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

Treatment	pH H_20	N %	OM %	BS %	P mgkg^{-1}	Ca Cmol kg^{-1}	Mg Cmol Kg^{-1}	K Cmol Kg^{-1}	Na Cmol Kg^{-1}	EA Cmol Kg^{-1}	ECEC Cmol Kg^{-1}
DS	5.79	0.32	0.91	85	18.00	4.00	1.63	0.07	0.10	1.12	7.28
CP	6.76	0.28	2.02	95	15.50	4.80	1.60	0.06	0.06	0.32	6.84
PC	8.34	0.56	1.32	99	30.60	3.60	1.35	0.04	0.08	0.08	5.42
GC	7.02	0.24	2.72	98	12.40	4.20	2.00	0.12	0.09	0.16	6.57
PGC	7.62	0.12	2.58	97	9.80	3.20	1.20	0.05	0.11	0.16	4.70
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= Non- significant.

Table 4b. Effect of compost and Earthworm production on the soil physical properties

Treatment	Sand %	Silt %	Clay%	Textural class
DS	70.60	1.40	28.00	Sandy Clay Loam SCL
CP	71.60	2.40	26.00	Sandy Clay loam SCL
PC	76.60	8.40	15.00	Loamy Sand LS
GC	70.60	8.40	21.00	Sandy Clay loam SCL
PGC	75.60	9.40	15.00	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= Non- significant.

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 activities of earthworm (Eurdrilus eugenae). The germination and growth of maize, as well as very short lived activities of earthworm observed on the polluted soil, was due to 8 months allowed for the soil before it was used for the potted experiment, because, the unpublished work (though presented as a Faculty Lecture), where by the same experimental crude oil polluted 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 as test crop, no sign of germination was observed on the polluted soil throughout the period of the experiment and earthworm (Eudrilus eugenae) did not survive for 24hrs on both the polluted and treated soils, though the guinea grass compost improve the germination and growth on the treated soils, they looked unhealthy and very tiny in structure.

Therefore based on the unpublished work and present study experiences, leaving an oil polluted soil no matter how heavily degraded for a while after plough and harrowing or soil removal alone can even be a good management strategy for an oil polluted land. By plough and harrowing grasses and shrubs covering the soil will be removed, the impact of sunshine and rainfall will be felt by the affected soil environment, in the sense that most of these hydrocarbons made up different carbon chains can be heated up, by the heat of the sun leading to breakup of some of these chains and many leaving the soil environment as a gas into the atmosphere. This because oil pollution shade the soil from receiving moisture because the oil portion is not mixable with soil water and this prevent proper aeration of the soil hence creating anaerobic condition by inhibiting the growth of plant and microbes (especially aerobic organisms) in the soil. Plough will also help to limit the movement of the oil films further into the soil sub layers. The mixing of the lower layer of the soil untouched by the crude oil and upper polluted layer can be a good omen for the soil and micro-organism activities. The grasses and shrubs ploughed under will encourage the activities of oil decomposing micro-organisms that will help break down the hydrocarbons, of which many will leave the soil as a gas and many transformed through microbial activities to other products not harmful to the soil or the crops that will grow on it. For instance Amakiri and Onofegara (1983) and Rowell (2003) observed that crude oil polluted 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 polluted 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 polluted 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); 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 (Eudrilus 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 4WAP 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. Paterson, (2003) 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, which 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 Martine (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 (Nweke, 2013), compost degradation, soil aeration due to earthworm burrowing within the maize root zone of soil and many other factors as was reported by Fagoso 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 activities in bioremediation and rehabilitating of poorly polluted or degraded soil. Earthworm help to turn wastes into resources and at the same time minimizes pollution (Edward 1998). There cast have been reported by Scheu (1997) and Parthasarathi et al., (2007) to be more biologically active and richer in micro flora than their surrounding indigested soils, 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 or polluted 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 weight and survival of *Eudrilus eugenae*

The result of this study showed that earthworm (Eudrilus Eugenae) can successfully thrive or cultured in an oil polluted 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 (Eudrilus 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 weight 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 weight 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 oil pollution 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 (Toxic form) that the maize plant can absorb them, because the result of soil chemical parameters presented on Table 4a indicated that the soil treated with CP are rich in soil nutrients. The zero (O) recorded for number and weight of earthworm in DS showed that no earthworm survived to harvest. Though there were earthworms 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 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 (Eudilus eugenae) using cassava peel as source of diet in crude oil polluted 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 activities 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 (Nweke 2013) 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 maybe fertile or rich in plant nutrient but may not promote crop growth and yield due to nutrients fixation, soil pathogens, nutrient deficiency, soil pH and environmental factors like oil pollution.

The exchangeable cations (Ca^{2+}; Mg^{2+}; K^+; Na^+) of the soil were influenced by the compost application and earthworm activities, 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 oil pollution 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 i.e. $H^+ + Al^{3+}$), 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 pollution has less effect on soil physical properties and that the texture of the soil polluted with oil has less significant changes. While SPDC (1998), argued that the structure of oil polluted soil maybe weaken 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 polluted 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, which signifies that an oil degraded or polluted 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 pollution 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.

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