# Effects of Composts and NPK Fertilizer on the Performance of Maize Plant in Crude Oil Polluted Soils

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## ABSTRACT

*Crude oil polluted soil in most cases do not yield good harvest for farmers. However, considering the growing need for food and other agricultural products, it is imperative to explore ways of utilizing the available farm land at our disposal. Hence, this experiment is set to evaluate the effects of composts and NPK fertilizer on the performance of maize plant in crude oil polluted soils. The site for this experiment was polluted with crude oil from the area. The polluted soils were later treated after two weeks with different composts composition (PW + SD + CR), (MW + SD + CR), (CD + SD + CR) and fertilizer and left for two weeks before maize were planted on the soils. Germination started very fast from the soil supplemented with fertilizer but growth related parameters plant height, stem girth, leaf area and number of leaves were noticed more in maize plants from soil treated with (PW + SD + CR). The order of performance and improvement by the treatments was as follows: (PW + SD + CR) > (CD + SD + CR) > (MW + CR + SD) > (Fertilizer) except in number of leaves. The performance of maize 5 WAP reflected that the toxicity of the crude oil had reduced and that the crude oil has being degraded with the residual crude oil added more organic matter to the soil and growth of the plants. The growth parameters of the maize were recorded and later harvested ten weeks after planting and their tissues analyzed for heavy metals possibly assimilated through developmental stages. Analysis of the plant tissues does not reflect any uptake of heavy metals in the soil by the maize plants. This study conclusively revealed that the adverse effect of crude oil can be cured using organic compost than the inorganic fertilizer that may have toxic and adverse effects on crops.*
**Keywords:** *Crude oil, Soil pollution, Remediation, Composts, Heavy metals.*

## INTRODUCTION

Exploration and production of crude oil, in Nigeria was envisaged to generate strong economic foundation for the country and better dwelling place for human and other living organisms. On the contrary, crude oil exploration has brought untold hardship to people living in the oil producing area regarding their health and living status. Therefore the achievement of sustainable and habitable environment cum environmentally sound agriculture in the fragile, inherently infertile soil with low productivity remains one of the greatest challenges facing people, most especially in oil producing area of Nigeria. Soil acts as sink for unpleasant materials and function as a filtering, buffering, storage and transformation system, thus it protect against the effects of elements pollution (Blum,


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Warkentin, and Frossard (2006). Soil is significantly effective in these functions only as long as the physical, chemical and its biological activities are preserved. Chemical properties of soils are important soil characteristics that regulate the availability of elements such as calcium (Ca), cobalt (Co), manganese (Mn), magnesium (Mg), potassium (K) which may be essential for plants nutrition. They are also important in regulating the undesirable side effects from plant protection chemicals such as selective herbicides and fungicides. The regulatory mechanisms involve a lot of interactions within the soil system, which then control the chemical composition of the plant root environment and hence nutrients availability to plants. In the oil polluted areas, soil and the environment suffer unabated pollution from oil spills. The problem of pollution from oil exploration is extensive. Various harmful and toxic organic compounds when introduced into the environment during oil extraction, oil spill, gas flares and several other forms of pollution, changes the geo-chemical composition of the soil, and other components of the environment. This in turn affects agriculture and lead to a drastic decline in output in both fishing and farming activities. Pollution from oil extraction can lead to soil erosion, ground water, marine water, air pollution and severe health problems for the communities in oil producing areas.

Unhealthy soil management methods have degraded soil quality, caused soil pollution, and enhanced erosion. Treating the soil with chemical fertilizer, pesticides, and fungicides interferes with the natural processes occurring within the soil and destroys useful organisms such as bacteria, fungi, and other microorganisms. This process indiscriminately kills the beneficial microorganisms and leaves the soil sterile and dependent upon fertilizer to support plants growth. This results in heavy fertilizer use and increases polluted runoff into lakes and streams (Engelking, 2003). Also, because of the absorptive and buffering properties of soil, some pollutants such, as Cu, Pb, PCB, petroleum hydrocarbon (PHCs) have long half-lives in the soil and food crops grown on these polluted soils may be affected by some pollutants. The absorptive nature of crops can reduce; hinder germination or growth and slow significant performance of the crops. Food crops are essential and important to man and animals but contaminated or polluted food crops can pose health risk and economic drawback. Bringing back the polluted soil to pre-contaminated level is important in view of significant severe effect of crude oil on both plants and animals, and physical ugliness effect in the oil polluted area, hence the need for this study.

## MATERIALS AND METHOD

Prior to the beginning and after the experiment, twenty random soil samples were collected at 0-10, 10-20, 20-30 cm depths with the aid of soil auger. The samples were bulked, mixed and representative samples taken for routine analysis. Crude oil was first added. Compost manure and fertilizer were added after addition of crude oil to the soil. In order to achieve the required nitrogen rate as well as supply of required phosphorus and potassium nutrients. The compost quantity added to the soil was 5.0 t $ha^{-1}$ while the fertilizer was 0.2 t $ha^{-1}$ of NPK. The compost mixtures used were:

1) Cow dung (CD), Saw dust (SD), Crop residue (CR), (CD + SD + CR);
2) Poultry waste (PW), Saw dust (SD), Crop residue (CR), (PW + SD + CR)
3) Market waste (MW), Crop residue (CR), Saw dust (SD), (MW + CR + SD).

They were added using top dressing method, while NPK fertilizer applied was by band method. Preliminary investigations were carried out on the soil before and after addition of crude oil to confirm the physical appearance and mineral contents by (APHA, 1995; DPR, 2002). The metals, Potassium (K), was determined by flame photometry while Calcium (Ca), Magnesium (Mg), Colbat (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Manganese (Mn). Chromium (Cr). Cadbium (Cd), Lead (Pb) and Iron (Fe) were determined by Atomic Absorption Spectrophotometer (AAS) (AOAC, 1990). The plants parameters were measured using descriptive statistics.

## RESULTS AND DISCUSSION

Oil pollution had deleterious effect on maize performance by altering soil physical, chemical and biological components, thus, affecting rate of synthesis and translocation of vital mineral elements in maize plants. While nutrient supplementation alleviates this adverse effect by increasing the nutrients reserve available for translocation in the soil. Initially maize did not sprout on the polluted soils. Those that showed signs of germination were entirely brown and withered off due to the toxic effect of the crude oil which was later suppressed by the microbial activities from compost. Proper germination of maize planted in the soils started after the soils had been amended with composts and fertilizer. Similar observation had earlier been reported (Treblay, Lee, and Levy 1993, Amadi, Dickson and Maate, 2004; Onibon and Fagbola, 2008).

The metal concentration before and after planting is presented on table 1. The presence of heavy metals in crude oil may inhibit the activities of minerals present in soils and hence low fertility of the soil and poor agricultural yield. The most abundant heavy metals present in crude oil are Vanadium (V) and Nickel (Ni) and the other metals identified in crude oil are Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe), Nickel (Ni), Sodium (Na), and Potassium (K) with sodium as the most abundant element in crude oil. The concentrations of some heavy metals measured in soil and plants vary significantly from each other with Fe 44.82 $\mu g\ g^{-1}$ as the most abundant element in the soil.

The metal contents in the plant tissues from soils treated with fertilizer are low in values compared to soils without fertilizer application. Manganese, Cu, Pb, Ni, Cd and Zn were not detected with only low values in Cr. 0.02 $\mu g\ g^{-1}$, Co – 0.15 $\mu g\ g^{-1}$, Fe 0.27 $\mu g\ g^{-1}$, Ca – 0.38 $\mu g\ g^{-1}$ and Mg 9.33 $\mu g\ g^{-1}$. In the remaining treatments (PW + SD + CR), (MW + SD + CR), and (CD + SD+ CR), the content of metals were significantly low in the market waste compost treated plants with heavy metals Cu, Pb, Ni and Zn not detected while Mn, Cr, and Cd were equal values, 0.05 $\mu g\ g^{-1}$, Fe, Co, Ca and Mg were respectively 0.42, 0.45, 0.96 and 9.53 $\mu g\ g^{-1}$. Only Cd and Zn were below detection limit in cowdung compost treated soil but had the highest record of

Mg 17.95 µg $g^{1}$ value. The lowest value of metal was recorded for the poultry waste treated soil. The plant tissue analysis does not show any significant presence of heavy and trace metals. The result shows the metal to be relatively low in plant tissues than the metals in the soil. Zinc was not detected in any of the plants while Cu with 0.02 µg $g^{-1}$ was detected in (CD + SD + CR) treated soils and not detected in the tissues of plants from other compost treated soils. The concentration of free copper ions in soil solutions is usually low copper and zinc availability decreases with increasing level of phosphates. Therefore the low level of zinc and copper in the tissue of plants is in line with various results. Despite its low concentration, maize did not absorb heavy and trace metals which were present in the soil. These low levels of metals were perhaps held on to by soil microbial activities for further degradation and remediation of oil polluted soils. The number of leaves, plant height, and stems girth and leaf area of maize are shown on tables 2 - 5.

The number of leaves in (MW + S.D + CR) and (PW + SD + CR) ranged between 13.75 and 15.25, 12 WAP. The mean values for the number of leaves from 2 to 12 WAP are 5.38, 7.12, 8.25, 10.50, 12.45 and 14.37 respectively. Comparative results of the effect of different composts on plant height of maize had the mean value results from 2 to 12 WAP as (CD + SD + CR) 24.29 to 72.94 cm, (PW + SD + CR), 25.91 to 72.78 cm, (MW + SD + CR) 23.94 to 71.13 cm, NPK fertilizer 21.74 to 65.35 cm. The average results of 65.35 cm to 72.94 cm in fertilizer and cow dung compost treated soils are significantly different at ($p < 0.05$). The mean stem girth values ranged from 4.75 cm in NPK fertilizer to 5.25 cm in (PW + SD CR) at 2 WAP and from 12.88 cm (MW + SD + CR) to 14.50 cm in (PW + SD +CR) compost treated soil. The mean values ranged from 5.03 cm at 2 WAP to 13.72 cm at 12 WAP. In the results, leaf area values ranged from 23.98 $cm^2$ to 26.33 $cm^2$ in maize from soils amended with compost market waste and NPK fertilizer. At 12 WAP, the values ranged from 74.38 $cm^2$ to 85.73 $cm^2$ in cow dung and poultry waste composts treated soils. The leaf area mean values ranged from 25 .00 $cm^2$ to 80.27 $cm^2$ between 2 and 12 WAP.

In general, the growth parameters recorded for maize crops from soil treated with poultry waste compost performed significantly better ($p < 0.05$) than the results obtained for maize from other composts and NPK fertilizer treated soils. These values were in agreement with (Amadi, Dickson, and Maate, 2004, Onibon and Fagbola 2013) results where maize treated with only sawdust had a very low results compared with the plant treated with only poultry manure. The trend of growth revealed quantitatively higher plant height, stem girth, number of leaves and leaf area as number of week's increases. Similar observation had earlier been reported (Treblay, Lee and Levy, 1993). All treatments enhanced growth of maize plant with highest growth parameters recorded in soils treated mostly with poultry and cow dung composts all through the study. Higher performance could be a result from further break down of hydrocarbon and more microbial activity leading to the release of nutrients, better soil condition enhancing growth.

Normal growth of maize including colour was observed in the first few weeks of the experiment. After the fifth week, maize plants in the treated soils were experiencing colour change and necrosis of the leaves. This observation is similar to (Onibon and Fagbola 2014). But in all the treatments, poultry compost supplemented soil performed significantly better than all the other composts used in this study. The high growth rate in the poultry waste compost supplemented soil may be as a result of the enhanced nutrient status and their slow rate of release in the soil. The observed increase in maize growth 3 WAP may be due to the amount of organic matter and combined nitrogen in the soil after biodegradation of the oil. Also, it was observed that poultry waste is high in nitrogen compared to other animal manures. Nitrogen and phosphorus elements majorly limit the biodegradation of oil and plant growth in addition to the wide ratio of C and N (C/N). With this development, plants will compete for the limited nutrients with outward effects on soil and a decrease in crop yield. But supplementation of soil with compost which ultimately releases these elements augments this severe condition and makes nutrients available to plants (Ajao, Okoye and Adekanbi, 1996; Duran, Ruban, Ambles and Oudot, 2004).

The improvement in plant growth after addition of poultry manure is attributable to the increased N, P and K supplied by the manure. Aside from ameliorating the soil fertility status, soil structure, permeability and soil moisture are conserved by nutrient supplementation. The low performance of the remaining composts may be due to much longer time required for effective decomposition and mineralization. Though the chemical fertilizer has the tendency to mineralize better than the compost, but its chemical toxicity to the microbes may have contributed significantly to low performance of maize.

## CONCLUDING REMARKS

This study is an experimentation of the Effects of Composts and NPK Fertilizer on the Performance of Maize Plant in Crude Oil Polluted Soils. It was observed that in the maize plant tissues, application of composts did not results in uptake of metals from the polluted soils into the maize plants. The variability and low values obtained from the plant tissues were significantly lower than the metal concentration in soil. The presence of trace crude oil does not have negative effect on growth and performance of plants due to remediation procedure from the contributions of nutrients supplementation and microbial degradation of oil in the soil. The results obtained in this study, therefore, reveal that crude oil polluted soil can be remediated using composts and for better cropping performance. Perhaps, increasing the rate of application of compost would lead to more nutrient composition and this may enhance maize/crops performance in oil polluted soils.

**Table 1:** Combined metal concentration ((µg g-1) in maize plant tissue and soils in crude oil polluted soil

| | Co | Ni | Cu | Zn | Mn | Mg | Fe | Cr | Pb | Cd | Ca |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (CD+SD+CR) | 0.46 | 0.18 | 0.02 | ND | 0.06 | 17.95 | 0.20 | 0.12 | 0,09 | ND | 0.54 |
| (PM+SD+CR) | 0.18 | 0.07 | ND | ND | 0.01 | 10.44 | 0.07 | ND | 0.16 | 0.04 | 0.73 |
| (MW+CR+SD) | 0.45 | ND | ND | ND | 0.05 | 9.53 | 0.42 | 0.05 | ND | 0.05 | 0.96 |
| Fertilizer | 0.15 | ND | ND | ND | ND | 9.33 | 0.27 | 0.02 | ND | ND | 0.38 |
| Unpolluted Soil | 0.51 | 1.16 | 1.10 | 0.04 | 0.89 | 9.58 | 0.67 | 0.29 | 0.07 | ND | 0.56 |
| Soil Without C.O | 0.45 | 0.68 | 1.25 | ND | 0.78 | 9.96 | 0.72 | 0.13 | 0.03 | 0.02 | 2.55 |
| Soil+C.O+Treatment | 0.03 | ND | ND | ND | 0.09 | 15.13 | 0.57 | ND | 0.05 | 0.03 | 0.21 |
| Soil + C.O | 0.63 | 0.54 | 0.77 | 0.05 | 1.46 | 16.70 | 1.50 | 0.38 | ND | ND | 0.88 |

C.O = Crude oil;
N.D = Not Detected
***Source***: Field experiment, 2014

**Table 2:** Effect of different treatments on number of leaves of maize in the second field experiment.

| | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| **Fertilizer treatment** | **2** | **4** | **6** | **8** | **10** | **12** |
| Cowdung | 5.25a | 6.75a | 8.75ab | 10.25a | 12.00ab | 13.75ab |
| Poultry Waste | 5.5a | 7.50a | 7.00a | 11.50a | 13.25a | 15.25a |
| Market Waste | 5.75a | 7.25ab | 8.75a | 10.25a | 12.00a | 13.75a |
| NPK | 5.00a | 6.75b | 8.50a | 10.00a | 12.25a | 14.00a |
| Mean | 5.38 | 7.12 | 8.25 | 10.50 | 12.45 | 14.37 |
| S.D | 0.32 | 0.38 | 0.84 | 0.77 | 0.65 | 0.71 |

*Values within the same column with similar letters are not significantly different according to Duncan Multiple Range Test (DMRT) at p < 0.05.* ***Source***: Field experiment, 2014

**Table 3:** Effect of different treatments on the plant height of maize in the combined first and second field experiments

| | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| **Fertilizer treatment** | **2** | **4** | **6** | **8** | **10** | **12** |
| Cowdung | 24.29a | 28.11a | 32.70a | 43.96a | 56.05b | 72.94a |
| Poultry Waste | 25.91a | 32.06a | 37.05a | 49.85a | 65.81a | 72.78a |
| Market Waste | 23.94ab | 29.29a | 35.53a | 49.36a | 62.03ab | 71.13a |
| NPK | 21.74b | 27.39a | 33.15a | 43.05a | 55.16b | 65.35a |
| Mean | 23.97 | 29.21 | 34.61 | 46.56 | 59.76 | 70.55 |
| S.D | 1.72 | 2.05 | 2.05 | 3.55 | 5.06 | 3.56 |

*Means with similar alphabets in each column are not significantly different at p < 0.05 according to Duncan Multiple Range Test (DMRT).* ***Source***: Field experiment, 2014

**Table 4:** Effect of different treatments on stem girth of maize in the combined field experiments

| | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| **Fertilizer treatment** | **2** | **4** | **6** | **8** | **10** | **12** |
| Cowdung | 5.00a | 6.38a | 8.25a | 9.88ab | 11.88ab | 13.63ab |
| Poultry Waste | 5.25a | 7.25a | 12.75a | 10.88a | 12.75a | 14.50a |
| Market Waste | 5.13a | 6.63a | 7.88a | 9.25b | 11.00b | 12.88b |
| NPK | 4.75a | 6.38a | 8.00a | 9.88ab | 12.00ab | 13.88ab |
| Mean | 5.03 | 6.66 | 9.22 | 9.97 | 11.91 | 13.72 |
| S.D | 0.21 | 0.41 | 2.36 | 0.67 | 0.72 | 0.67 |

*Means with similar letter(s) in each column are not significantly different at p < 0.05 according to Duncan Multiple Range Test (DMRT).* ***Source***: Field experiment, 2014

**Table 5:** Effect of different treatments on leaf area of maize in the combined field experiments

| | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| **Fertilizer treatment** | **2** | **4** | **6** | **8** | **10** | **12** |
| Cowdung | 24.24b | 32.69a | 42.69ab | 54.54b | 65.98b | 74.38a |
| Poultry Waste | 25.14ab | 33.48a | 42.91a | 58.11a | 68.46ab | 85.73a |
| Market Waste | 23.98b | 32.69a | 41.60b | 54.61b | 69.44a | 78.74a |
| NPK | 26.33a | 34.46a | 42.01ab | 54.81b | 65.34b | 82.24a |
| Mean | 25.00 | 33.33 | 42.30 | 55.52 | 67.30 | 80.27 |
| S.D | 1.10 | 0.84 | 0.61 | 1.73 | 1.96 | 4.86 |

Means with similar alphabets in each column are not significantly different at $p < 0.05$ according to Duncan Multiple Range Test (DMRT). ***Source***: Field experiment, 2014

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