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SCREENING OF MAIZE (*Zea mays* L.) FOR PHYTOREMEDIATION ON CRUDE OIL CONTAMINATED SOIL

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ABSTRACT

This study aimed at determining the phytoremediation latent of maize (*Zea mays*) on crude oil-contaminated soil. It involved the collection of maize seeds and growing it on a simulated oil spill contaminated soil with treatments at 25%, 50% and 75% w/w crude oil, alongside a control group. The experimental design was randomized; having three replicates, and was observed for fourteen days. Germination and growth parameters such as number of leaves, height of plant and stem girth was observed, and recorded. The result confirmed that crude oil had effects on the increase limit. The highest height recorded for the control with mean height of 57.85cm. The control group had mean value of 7.41 as the utmost quantity of leaves. The 25g treatment group recorded 8.62cm^2, which was the highest recorded stem girth, followed by the control with mean value of 8.18cm^2. From the soil analysis the metal status examined in the control group varied significantly from the crude oil contaminated soil. However, the study proves that the plant has phytoremediation capacity and hence can be utilized in phytoremediation of crude oil polluted soil.

Keywords: Crude oil, growth parameters, heavy metals, maize, phytoremediation

INTRODUCTION

In their natural state, crude oil is a multifaceted blend of hydrocarbons that is liquid and classified into aromatic, alicyclic, and aliphatic compounds (Ekpo and Ebeagwu, 2009). The majority of these rudiments are identified as poisonous to various biomasses in nature, which has created significant concerns about crude oil pollution, particularly on arable agricultural land. Although contamination of soils by oil spills is prevalent worldwide, it is frequently recorded in low technology nations.

In Nigeria, a large amount of crude is spilled annually into the environment. There were about 2,000 spills in Nigeria between 1976 and 1988 which involved about $2x10^6$ barrels of crude oil into the surroundings. Crude oil has been demonstrated to have a variety of negative impacts on both plants and microbes when allowed into the surroundings (Ekpo and Nwankpa, 2005). The existence of spills in soil decreases aeration of soils by obstructing the passage of air between the soil particles resulting in a state of anaerobiosis which trigger root strain in plant, reducing leaf growth and retarding the plant growth (Ekpo and Nwankpa, 2005).

Nigeria and the rest of the globe rely heavily on crude oil and petroleum products for energy. Oil has a significant impact on the world's economic and political future. Odjegba and Otebe (2007) reported that Petroleum industry has ushered in a major boom for the Nigerian economy while simultaneously causing environmental and socio - economic problems as crude oil exploration and exploitation occurs in locations that are remote and transported in massive quantities for refining, and for the derivation of its useful by-products. During transportation, and with the use of oceanic tankers and pipelines overland, operational discharge and accidental spills occur resulting to the initiation of exceptionally large quantities of crude oil into the sea bodies and land.

Agbogidi *et al.* (2007) reported that the discharge of crude oil on land negatively impacts the physicochemical composition of soils there by triggering harmful effect on plant growth and germination. The introduction of these hydrocarbons from crude oil in soils leads to increased deposition of heavy metals and other hydrocarbon components, and a decrease in soil fertility and plant toxicity, lowering agricultural yields (Odjegba and Otebe, 2007).

Crude oil effluence is an expected occurrence in oil producing and consuming regions around the universe (Agbogidi and Eshegbeyi, 2006). It stems from individual mistake and accidental discharges (Agbogidi and Ayelo, 2010). The severity of oil pollution, in effect varies with the quantity of crude spilled, the plant species in the spill location, the plant age, plant response to the crude oil composition alongside other environmental factors (Vwioko *et al.*, 2006; Agbogidi, 2009).

Oil contamination is a functional and an almost inevitable for an oil-based technology and economy dependent country like Nigeria. This calls for attention in all facets of the business of the growing population. The steady rise in exploration, production, refining distribution of oil and the uses of products and byproducts have occasioned to the massive discharge of crude oil.

These activities have led to widespread infectivity of mainly arable farmland, creeks, swamps and rivers with hydrocarbon and dispersant products in the distinct regions of the earth, particularly Niger Delta (Ogbonna *et al.*, 2007). Pollution from Crude Oil and its by-products in these habitats constitute public health hazards, socioeconomic hazards and environmental degradation, more visible in agricultural viable soil. Consequently, oil producing communities are faced with agricultural crisis arising from the interface of environmental, biological and socioeconomic restrictions resulting from the aftermath of pollution.

The present uprising in environmental contamination is due to oil mineral extraction and the implications on the soil and plant health has been issues of global and individual concern. Similarly, the indiscriminate sabotage and rupture of pipelines, corrosion and damages of pipelines has occasioned to poor crop plant performance in both commercial and subsistence farming system.

This crude oil usually reaches this soil via erosion, seepage and self-disposal thereby reaching farmlands influencing the increase, survival, and the plant produce. Hence, this study is relevant in that it will effectively reveal the tolerance level of the maize plant to crude oil toxicity while also providing information on its phytoremediation potential. This will provide a benchmark for researchers, government, and the public on the effects oil spill resulting from sabotage, bunkering, and improper management of pipelines on the enlargement and survival of the maize plants.

The study therefore aimed to assess the phytoremediation potentials of maize (*Zea mays* L.) on soil pollution occasioned by crude oil. Specifically, the objectives of the study are to: evaluate the germination characteristics of maize in crude oil impure soil and ascertain the consequence of crude oil infected soil on the plant growth parameters.

MATERIALS AND METHODS

***Study Area*:** The experiment site was the nursery site of the Department of Botany, Delta State University, Abraka, Delta State, Nigeria. Abraka is in Ethiope East Local Government Area of Delta State. It is located between longitude 6° and 6° 15E to the Greenwich meridian and latitude 5° 45' and 5° 50' of the Equator located at the South Bank River Ethiope spanning across several communities that are aligned linearly along the new and old Sapele-Agbor highway. Abraka is coastal plain territory, a lowland, flat and gently sloping towards the Ethiope River. The climate is equatorial, hot (23 to 37°C) and humid (relative humidity, 50 to 70 %), annual rainfall of 3,317 mm, vegetation; rainforest most of which have been replaced with farmland and secondary forest. Soil pH; 4.0-5.0, soil type: sandy 90% (Irwin and Efobo, 2013).

***Source of soil samples*:** Collected sample was from a farm site with the aid of a shovel at a depth of 10 – 15cm from a loamy soil land at Site 2, Delta State University, Abraka without pollution history. Collected soil was sieved to eradicate pebbles, grits, roots, and other materials that may be detrimental to seedling.

***Source of seedlings*:** Maize seeds were purchased from Abraka Main Market in Ethiope East Local Government Area, Delta State.

Source of crude oil: Crude oil for this experimental study was collected from Ebedei flow station oil well in Ukwani Local Government Area, Delta State.

Experimental setup: The test was performed in two sets of three (3) replicates in a complete randomized block design. Thirty-three (33) plant bags were used randomly with each bag containing 4 kg of soil. The test soil samples were contaminated with crude oil in the concentrations of 25%, 50% and 75% w/w. The control experiment was without used-engine oil.

Determination of Growth Parameters: Germination was observed from the first day of sprouting to day fourteen. The height of the plants was decided by using a meter rule to measure the plant from the bottom to the buds of each plant. Leaf attached from the plant was counted to know the total number of leaves attached to the plant. Percentage germination was determined by observing the germinated plants and dividing it by the total seeds sown.

Heavy Metal Analysis: Soil heavy metal analysis was carried out using standard methods. Five grams of the air-dried soil model was assimilated in acid mixture prepared from 20 mL HNO_3, 10 mL HCL and 2mL HF and heated on a hot plate (130 ^oC) for 2 hours while continuously stirring. The combination was filtered, and the solution made up to 100 mL using distilled water. Flame Atomic Absorption Spectrophotometry was used to test for heavy metals (Fe, Zn, and Ni) (Perkin Elmer Analyst 200). Samples were analyzed in triplicates.

Data Analysis: **Analysis of Variance (ANOVA)** was employed for analyzing the mean and the difference.

RESULTS

The results from experiment conducted on the crude oil's effects on seed gravidity, growth and survival of maize plants after fourteen days of germination on crude oil impacted soil are presented below. Table 1 gives the percentage germination of maize plants grown on different treatment levels used in this research, alongside the control. It shows crude oil's impact on the height of maize plants grown on different treatment concentrations soil fourteen days after germination. The outcome revealed that the different concentration influenced the plant height as the days progresses. The sample with the highest recorded height was the control group with mean elevation of 57.85 cm. Next was the 25% treatment soil which recorded a mean of 54.35cm, followed by 50% treatment soil with mean elevation of 23.51cm. The lowest recorded height was in the 75% treated soil with a mean value of 21.82cm.

Table 1: Effect of crude oil on plant height (cm) of maize

Concentrations	DAYS							Mean
	2	4	6	8	10	12	14	
Control (0.0)	0.0	49.3	60.0	66.6	69.6	75.6	83.9	57.85^a
25%	0.0	42.6	55.0	61.6	65.3	72.0	84.0	54.35^b
50%	0.0	18	20.0	24.3	30.3	34.0	38.0	23.51^c
75%	0.0	12.6	17.0	26.3	29.3	31.6	36.0	21.82^d

Means with different alphabet in the same column are significantly different (P < 0.05) using ANOVA

Table 2 presents the effect of crude oil treated soils (25%, 50% and 75%) on the number of leaves of maize grown after fourteen days of germination. It was noted that the existence of crude oil had a negative outcome on the plants in contrast to the control which had mean value of 7.41 with the greatest number of leaves. The 25% treatment concentration soil witnessed the maximum compared to other treatment groups with mean number of leaves of 6.17 which was followed by 50% treatment soil (3.11) and 75% treatment concentration soil (2.92).

Table 2: Effect of crude oil on number of leaves of maize plant

Concentrations	DAYS							Mean
	2	4	6	8	10	12	14	
Control (0.0)	0.0	3.0	8.3	8.3	10.0	10.0	12.3	7.41
25%	0.0	3.0	7.6	5.3	9.0	9.0	9.3	6.17
50%	0.0	1.3	3.6	4.0	4.3	4.3	4.3	3.11
75%	0.0	1.6	3.3	3.6	4.0	4.0	4.0	2.92

Means with different alphabet in the same column are significantly different (P<0.05) using ANOVA

Table 3 shows the stem girth (cm^2) of plants in different treatment concentration (25%, 50% and 75%) of crude oil polluted soils. The result suggests that different treatment concentrations impacted on the stem girth of the maize plants. From observation, the 25% treatment soil recorded the highest stem girth with a mean value of 8.62cm^2 followed by the control with mean value of 8.18cm^2. The 75% treatment had a mean stem girth of 4.34cm^2 while the least recorded was in the 50% treatment soil with mean value of 3.21cm^2.

Table 3: Effect of crude oil on the stem girth (cm^2) of maize plant

Concentrations	DAYS							Mean
	2	4	6	8	10	12	14	
Control (0.0)	0.0	6.0	8.3	10.0	11.0	11.0	11.0	8.18
25%	0.0	6.0	9.3	10.3	11.6	11.6	11.6	8.62
50%	0.0	1.3	1.3	4.3	5.0	5.3	5.3	3.21
75%	0.0	3.3	5.0	5.3	5.6	5.6	5.6	4.34

Means with different alphabet in the same column are significantly different (P<0.05) using ANOVA

Tables 4 and 5 below show the heavy metal status at the third and sixth weeks respectively for the control group and different treatment groups. Results in Tables 4 and 5 proved that the heavy metal status of the control varied significantly from the polluted simulated soil. Results also showed that the soil heavy metal status with maize plants had lower values compared to treated soil without maize plant.

Table 4: Heavy metal status of crude oil contaminated soil at the third week

Concentrations (g)	Heavy Metals		
	Iron (Fe)	Zinc (Zn)	Nickel (Ni)
Control	18.96	0.09	0.09
25% crude oil	74.71	2.46	0.23
25% crude oil + maize	68.43	2.01	0.20
50% crude oil	93.92	2.19	1.38
50% crude oil + maize	69.74	2.08	0.96
75% crude oil	123.01	2.47	1.76
75% crude oil + maize	91.94	2.13	1.61

Table 5: Heavy metal status of crude oil contaminated soil at the sixth week

Concentrations (g)	Heavy Metals		
	Iron (Fe)	Zinc (Zn)	Nickel (Ni)
Control	11.20	0.09	0.09
25% crude oil	77.98	2.00	0.21
25% crude oil + maize	63.20	1.73	0.17
50% crude oil	88.95	2.15	1.32
50% crude oil + maize	61.07	1.94	0.27
75% crude oil	106.42	2.42	1.76
75% crude oil + maize	82.94	1.77	0.91

DISCUSSION

The results of this study showed marked difference between the plants grown in soils polluted with crude oil and those in non-crude oil-polluted soil. The sprouting and development parameters of Maize (*Zea mays)* recorded highest in non-crude oil-infected soils compared to the ones developed in soils infected by crude oil. Observation from this research is similar to the result reported by Oyedeji *et al.* (2012) on the consequence of crude oil on economic growth of *A. esculetus* at varying concentrations.

The result confirmed that non treated soil had better growth compared to treated soil. It also established that germination rate was also dependent on the therapy focus. Due to the negative impacts of oil effluence on the soil, there are considerable impacts on plant increase (Anoliefo *et al*., 2006; Bamidele *et al*., 2007). The findings of this research is similar to the result reported by Ekpo and Ebeagwu (2009) who reported that at a higher oil pollution level of 3 and 6%, the emergence and increase of some seeds of *Telfaria occidentalis* was significantly delayed.

The influence of crude oil on the sprouting loftiness of maize plants in treated soils revealed that there were substantial differences between plants developed in non-crude oil-infected soil and those growing in crude oil-infected soil. Statistical analysis demonstrated that plants developed in non-infected soil with crude oil outperformed the ones developed in crude oil-infected soil, regardless of the oil content. Plant performance in crude oil-polluted soils is concentration dependent.

Crude oil's influence was noted in different treatment concentrations on several leaves and stem girth of maize plant observed the stunted plant girths in the crude oil-infected soils, and with reduced leaves compared to plants developed in non-crude oil-infected soil. The existence of crude oil in the soil in which the seedlings were grown, however, was blamed for the decrease in seedling leaves and girths. Soil is a critical constituent of the farming ecosystem, and its long-term viability is dependent on adequate soil care and management (Adenipekun and Kassim, 2006).

For best agricultural productivity, the soil on which agriculture relies must be used sustainably. Soil pollution caused by crude oil poses a serious threat to agricultural output, resulting lack and starvation among the population (Adenipekun and Kassim, 2006). Oil in agricultural soils has an effect on agricultural productivity, based on the result of this investigation. Oil effluence, in any form, is hazardous to plants and soil microenvironments in agricultural soils.

The existence of crude oil in the plant-soil micro surroundings has an impact on usual soil chemistry, resulting in vitamin assimilation and a decrease in the quantity of water accessible to the plant. The lack of appropriate water, which affects vitamin absorption and movement, may be to blame for the decline in plant tallness and girths in crude oil-infected soil (Oyedeji *et al.*, 2012). This study reveals that introducing crude oil to agricultural soil has significant negative and harsh impacts on plant sprouting, plant makeup and ecosystem, and natural increase and maturity of several vegetable crops in the Niger Delta region.

Plant parameters including plant height, stem girth, and number of leaves responded to the presence of crude oil in the study. This corresponds with the report of Vwioko and Fashemi (2005) that *Ricinus communis* (Castor oil) grown on lubricating oil infected soil stimulated growth, influencing root length, leaf area, and the dry and fresh weight. In the work done by Edema (2010), *Jatropha curcas* grown in crude oil infected soil initiated auxiliary bud formation and showing increasing quantity of leaves with increasing crude oil concentration contrasting with the current research as there was a decline in the leaf number, and other growth parameters.

Determination of soil heavy metal status disclosed that there was decline in the intense metal substance in soil containing maize plants compared to treatment soils without maize plants. However, phytoremediation which involves utilizing plants alongside its associated soil microorganisms in reduction of contaminant and their effects on the environment (Huang *et al.,* 2006) is achievable using the maize plant.

The conventional methods of phytoremediation which include soil extraction and landfill of the top contaminated soils ex situ is highly effective and clear-cutting (Zhu *et al.*, 2004). Hence, in situ bioremediation, the function of plants such as maize could be suggested and as one of the preferred methods for the remediation of petroleum-contaminated site because it is cost-effective and naturally converts the hydrocarbons to harmless byproducts such as carbon dioxide and water. The contaminated soil is not moved elsewhere as with land filling, and easier to scale up to treat large volume of wastes. Designing in situ bioremediation under specific on-site conditions, on the other hand, may remain a difficult task (Huang *et al.,* 2006).

CONCLUSION

The study had evaluated the germination characteristics of maize in crude oil impacted soil and ascertained the consequence of crude oil impacted soil on the plant growth parameters. Based on the results obtained from this study, the plant might be used for phytoremediation of crude oil polluted soil.

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