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EFFECT OF CRUDE OIL POLLUTION ON SOIL CHARACTERISTICS AND PERFORMANCE OF MAIZE (ZEA MAYS) IN OBIO AKPA, AKWA IBOM STATE, NIGERIA

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ABSTRACT: *A pot experiment was carried out to study the effect of different levels of crude oil on soil characteristics and performance of maize (ZEA MAYS). The experimental was laid out in completely randomized design (CRD) in three replications and four (4) levels of crude oil treatments (0,2,5 and 10 % crude oil) was applied. Soils were analyzed before and after treatment. Data were assessed using the analysis of variance and significant means were separated using the least significant difference (LSD) at 5% probability level. Results showed that different levels of crude oil treatment significantly ($P\leq0.05$) affected soil pH and organic carbon content, as they increase significantly ($P\leq0.05$) above that of the control (0%). On the other hand, for available P, exchangeable Ca, exchange acidity and ECEC, significant decreases were observed. Crude oil treatment produced significant reductions in the growth (number of leaves, leaf area, and plant height and stem girth) of maize plants. Proximate composition of maize was determined 28 days after emergence. The growth was attributed to suffocation of the plant caused by exclusion of air by the oil or exhaustion of oxygen by increased microbial activity, interference with plant-soil-water relationship.*

KEYWORDS: Zea Mays, Proximate, Exchangeable, Microbial and Suffocation

INTRODUCTION

Maize also referred to as corn or Indian corn in the United States and Great Britain respectively is a cereal plant of the Graminea family of grasses that today constitutes the most widely distributed food plant in the world. However, little of this maize is consumed directly by humans: most is used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. The food and agricultural Organization (FAO) also maintained that each part of maize which are the cob, stalk, silk and the leaves are of economic value and the kernel being the most useful. Hence, maize is a universal crop species.

The Study Site

The research was conducted in the Akwa Ibom state University, Obio Akpa Teaching and Research Green House. The study sites lies between latitudes $4^{0}30^{1}$N and $5^{o}30^{1}$N and longitudes $7^{o}30^{1}$E and 8^{1}E of Greenwich meridian (SLUSH-AK 1989). The area has a humid tropical climate characterized by two seasons; wet and dry seasons. The wet season start with heavy amount of rainfall sometimes accompanied by high velocity of wind, and the dry season with severe intensity of sunlight experience in the early hours of the day and usually set in the evening (Enwezon *et al.*, 1990). Rainfall pattern is bi-omodal with peak in June and September (Ukpong, 1992). The highest temperature (32^{o}C) is experienced during the month of February through March and coincides with the overhead passage of the Sun (Enwezor, 1990).

Vegetation and Land Use of the Study Area

The state is located within the humid forest of Nigeria, due to population pressure and increasing number of settlements, there is a drastic transformation of the natural vegetation. The overall effect is that the large area has been used for cultivation of subsistence crops like cassava, maize, plantains, vegetables, yam, cocoyam, oil palm are the features in the study area. The predominant land use in the state is farming. Human interaction and intervention through agriculture, construction, fuel wood and timber forest products have greatly influenced and alter the vegetation in the area.

Experimental Materials

The materials used for the experiment were maize seed (*Zea mays* – VARYZPB-SRW644-31). This variety when grown in rain fed conditions is known to be resistance to diseases, insect, logging. It is a good quality yielding variety, and crude oil: Bonny light.

Sources of Crude Oil

The crude oil used as pollutant for the experiment was obtained from Exxon Mobil flow station at Mkpanak, Ibeno LGA. It was a fresh Bonny light crude oil with relative density (Specific Gravity) of about 0.835 kg/m^3 as determined by the methods of AOAC (1990).

Soil Sampling

72kg of soil samples (0-15cm) depth was randomly collected from Teaching and research farm of agriculture, Akwa Ibom State University, Obio Akpa campus. The sample were air dried, crushed and sieved through a 2mm mesh sieve for routine laboratory analysis using standard laboratory procedures as described by (Udo et al., 2009).

Experimental Procedure

Seventy-two (72) kilograms of top soil (0-15cm) was collected from the Akwa Ibom State University Teaching and research farm for the experiment. The soil was taken to the green house, harmonized, divided into four (4) (18kg each) and respectively treated to 2, 5 and 10% (w/w). With bonny light crude oil of relative density (Specific gravity) of 0.835kg/m^3 at 25^{o}c. Six (6) kilogram of each simulated level was transferred into 4 polythene bags. They were 12 experimental units. The experiment was replicated three (3) times, completely randomized, arranged in a green house and allowed to settle for seven (7) days, then five (5) maize seed were planted per bag and thinned to three (3) seedlings, seven (7) days after plant emergence. During the study period, the experiment was kept moisten at field capacity using watering can. Twenty-eight (28) days there after the plants were manually and gently uprooted from each bag for the determination of moisture content, Fat, Ash, Carbohydrates and crude protein.

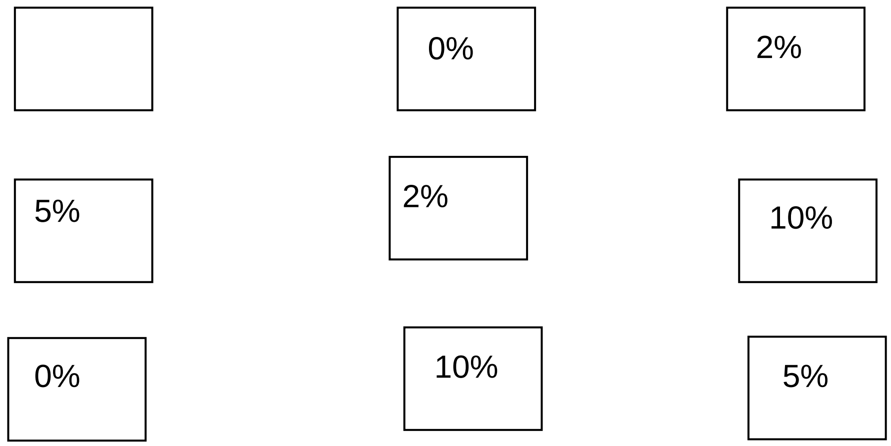

Fig. 1

Sampling of Test Plant

After plant emergency, plant height was measured using a meter rule. Leaf area was obtained by measuring the length and the breath of the longest leaf and multiplied by 0.75; stem girth was determined by using a string tied around the plant and the length of the string read from a meter rule. Numbers of leaf was determined by chopped and oven-dried at 70^{o}c to constant weight in a gallenkamp oven to determined moisture and dry matter contents, crude protein, Carbohydrates, Ash, and %moisture content.

PROXIMATE ANALYSIS

Determination of Moisture Content

The moisture dish was accurately weighed. Approximately 1.0g of the samples was added and then reweighed. It was then kept in vacumn oven for five hours. The dish washer removed from the oven, cooled and reweighed. This was repeated until a constant weight was obtained.

Determination of Ash Content

Procedures: 5g of the samples was accurately weighed in a crucible which has been dried. The crucible was then dried in oven at 100^{o}c. It was then transferred to muffle furnace and temperature increases to 550+-5^{o}c. This was maintained for 8 hours until a white and was obtained. The crucible was removed from the desiccators and weighed soon after cooling.

Determination of crude protein procedures:

The crude protein was determined using micro Kjeldhal method as described by AOAC (2000).

%N (wet)= $(A-B)^3$ 1.4007 x 100

weigh (g) of sample A=volume (ml) STD HCL^3 normality of std HCL

B = Volume (ml) std $NaOH^3$ normality of std NaOH

Determination of total carbohydrates

This was done conveniently by method of difference

Total Carbohydrates = 100- (% lipid +% ash + %moisture + %protein).

SOIL SAMPLES

The sample were air dried, crushed and sieved for routine laboratory using standard laboratory procedures as described by (Udo *et al.,* 2009). Before treatment and at the end of the study the soil used for this experiment was obtained air dried, sieved and analyzed for the following parameters:

Soil pH: This was determined potentionmetrically using glass electrode as described by Udo *et al.,* (2009) in 1:2.5 soil to water ratio.

Total Nitrogen: Total nitrogen was determined using macro Kjeldal method as outlined by Udo *et al.,* (2009).

Available Phosphorus: Available phosphorus was determined using Bray I method as outlined by Udo *et al.,* (2009).

Exchangeable Bases: Ca, Mg,K and Na was extracted with IM NH40AC (pH) Ca and Mg were extracted by *Udo et al.,* (2009).

Exchangeable Acidity: (H+ and AI3+) Exchange acidity was extracted with IN KCL solution and the acidity from the extracts was measured by 0.01M NaOH as described by Udo *et al.,* (2009).

Effective Cation Exchange capacity Titration (ECEC): This was obtained by the summation of exchangeable cations and acidity as described by Udo *et al.,* (2009).

Percent base Saturation: Percent base saturation (% BS) was determined by the relationship:

$$\%BS = \frac{\text{Summation of exchangeable bases}}{\text{ECEC}} \times \frac{100}{1}$$

Organic Carbon: This was determined by Walkey and Black Wet oxidation method (Nelson & Sommers, 1982).

Statistical Analysis

Data were assessed using the analysis of variance and significant means were separated using the least significant difference 5% probability level.

RESULTS

Some properties of the experimental soil are presented on Table 1. The most dominant soil particle was sand (89%) while silt (4.1 %) and clay (6.9%) fractions were low.

Soil pH in the study area was moderately acidic (5.6), reflecting the acid sands parent materials from which the soils of the area are derived. Electrical conductivity (EC) was low in the area (0.2 dSm^{-1}), an indication that the soils are non-saline.

Organic carbon content was moderate (1.23%), (2012); Total N was moderate (0.17%) and available P was high (25.00 mg kg^{-1} based on the classification of Chude *et al.* Exchangeable Ca, Mg, K and Na were 5.64, 2.67, 0.34 and 0.16 cmol kg^{-1}, respectively. The concentration of Ca, Mg and K were in tandem with the acceptable limits for crop production while K was low. Exchangeable acidity was 1.9 cmol kg^{-1}, ECEC was 10.71 cmol kg^{-1} while base saturation was high (82.26%).

The soils were fairly fertile but adequate for arable crop production.

Table 1 Some Physicochemical Properties of the soil before treatment

Soil Property	Value
Sand (%)	89.0
Silt (%)	4.1
Clay (%)	6.9
Ph	5.6
EC (dSm^{-1})	0.2
OC (%)	1.23
TN (%)	0.17
AP (mg kg^{-1})	25.00
Ca (cmol kg^{-1})	5.64
Mg (cmol kg^{-1})	2.67
K (cmol kg^{-1})	0.34
Na (cmol kg^{-1})	0.16
EA (cmol kg^{-1})	1.9
ECEC (cmol kg^{-1})	10.71
BS (%)	82.26

TP=Total Porosity, EC – electrical conductivity, OC – Organic carbon, TN- Total Nitrogen, AP – available P, EA-Exchange acidity, BS- base saturation.

After the experiment, there were no significant difference in sand, silt and clay fractions of the soil and consequently, soil texture remained the same as that observed prior to the study.

The non –significant effect of crude oil treatment can be attributed to the fact that soil texture, which is defined by the content of sand, silt and clay, is an inherent soil property which cannot be altered by soil management.

Soil pH and Electrical Conductivity

The pH of the soil in which crude oil was not applied (0%) and that of the pre-study soils were both moderately acid (Table 1 and 2). However, high soil pH values of 6.48, 6.71 and 6.75 were observed in soils that received 2,5 and 10% crude oil treatment respectively. Though the values seemed to increase wit increase in crude oil level, there was no significant difference between them. The results of previous studies on crude oil impacted soils in China showed that crude oil raised soil pH (Jia *et al.*, 2009, Wang *et al.*, 2010) and this is supported by the result of this study. The higher pH values in crude oil-polluted soil in this study might be attributed to the fact that oil pollution in soil has been shown to be associated with the accumulation of exchangeable Na+ and a reduction in exchangeable acidity and effective cation exchange capacity (ECEC) (Benka – Coker and Ekundayo, 1995; Ekundayo and Obuekwe, 1997; Agbogidi *et al.*, 2007).

Electrical conductivity was significantly ($P \leq 0.05$) affected by crude oil with soils that received no crude oil treatment (0%) having significantly ($P \leq 0.05$) higher EC than those treated with crude oil at different levels. However, values of electrical conductivity were generally low, depicting the non-saline nature of soils of the study area (Udo et al., 2009).

Organic Carbon

Organic carbon content of soils that received no crude oil treatment was significantly ($P \leq 0.05$) lower than those of soils that received different levels of crude oil treatment. The high organic carbon content observed in this study corroborated Wang et al. (2009; 2010) who reported that oil contamination significantly ($P \leq 0.05$) the organic carbon contents of soils.

Total N was not significantly ($P \leq 0.05$) affected by crude oil treatment at different levels of treatment.

Available Phosphorus

Available P was significantly ($P \leq 0.05$) higher in soils that received no crude oil treatment than in soils that received different levels of crude oil applications. The results of previous studies equally showed that oil contamination decreased available phosphorus concentration by various degrees (Wang *et al.*, 2009; 2010).

In this study, the reason for the decrease in available P with crude oil contamination could be linked to the increase in carbon concentration, which might have affected the equilibrium of nutrients in the soil. Microbes in soils, which utilize petroleum hydrocarbon as a carbon source, could utilize considerable amounts of available phosphorus when the degrade the hydrocarbons (Wang *et al.*, 2009).

Basic Cations (Ca, Mg, Na and K)

Calcium was significantly (Po.05) affected by crude oil treatment with soils that received no crude oil having significantly (P≤0.05) higher concentration of exchangeable Ca than those that did not received (Table 2).

Exchangeable acidity, effective Cation Exchange Capacity and Base Saturation

Exchangeable acidity and ECEC were significantly (P≤0.05) higher in soils that received no crude oil treatment than in soils that received different levels of crude oil applications (Table 2). These values of base saturation obtained after the treatment of crude oil were generally higher that that observed before the treatment.

Table 2: Means of physicochemical properties of the soil after treatment

	Crude Oil Level				
Soil Property	0%	2%	5%	10%	LSD (0.05)
Sand (%)	87.0	86.70	87.83	86.08	1.97 NS
Silt (%)	5.00	5.10	4.93	4.55	1.28 NS
Clay (%)	7.50	8.20	7.23	9.37	1.44 NS
Texture	Ls	Ls	Is	Ls	
Ph	5.57	6.48	6.71	6.75	0.21**
EC (dSm^{-1})	0.2	0.08	0.07	0.06	0.09 NS
OC (%)	1.29	6.66	6.89	5.88	1.58**
TN (%)	0.10	0.12	0.13	0.09	0.03 NS
AP (mg kg^{-1})	25.53	9.16	7.59	6.55	4.72**
Ca (cmol kg^{-1})	4.98	3.77	3.82	3.21	0.62**
Mg (cmol kg^{-1})	2.12	1.82	1.73	1.64	0.46 NS
K (cmol kg^{-1})	0.06	0.08	0.08	0.09	0.08 NS
Na (cmol kg^{-1})	0.07	0.10	0.11	0.11	0.03 NS
EA (cmol kg^{-1})	2.75	1.55	1.80	1.73	0.54**
ECEC (cmol kg^{-1})	9.97	7.31	7.54	6.77	0.94**
BS (%)					82.26

EC – electrical conductivity, OM – Organic Matter, TN- Total Nitrogen, Av.P – available P, EA-Exchange acidity, ECEC- Effective cation exchange capacity, BS- base saturation, LSD (0.05)- least significance at 5% probability level, NS- not significant.

Seed Emergence

Maize germination was affected by the treatment of soil, in high treatment level, germination was not only delayed but the percentage of germination was greatly reduced. The result showed that there was significant difference between the level of crude oil treatment soil. Seed grown in treated soil was significantly higher than those grown in untreated soil. These observations agree with the findings of Plice (2008). Murphy noted that the small amount of crude oil would delay germination and larger amount might even stop germination entirely.

Plice (2008) noted that violatile fractions of oil had a high wetting capacity and penetrating power. If in contact with a seed coat and readily kill the embryo.

Table 3: Effect of Crude oil treatment on maize

Crude oil Level (%)	Germination rate (%)
0	5.00[a]
2	4.33 [a]
5	3.66 [b]
10	3.00 [c]

abc means on the same row with different superscript are significantly different.

Effect of crude oil on maize performance

The performance of the maize (Zea Mays) plant after germination was seriously affected by crude oil treatment. Growth was generally poor in the treatment soil samples. The higher the level of crude oil treatment, the poorer the performance of the maize seedlings. The affected maize plant showed general chlorosisi of the leaves and with high levels of crude oil application, the plant tended to dehydrate indicating water deficiency. Growth was stunted and there was an eventual death of the growing points.

Plant Height

The treatment of soil with crude oil significantly influenced the growth parameters. 3 weeks after planting, 15.00cm, 11.00cm and 8.00cm was recorded for seedlings grown in 2%, 5%, 10% w/w when compared with that grown in untreated (0%) having the highest height with mean value of 18.00cm (fig.1). At 6weeks plant height was observed to have mean values of 19.00cm, 15.00cm and 12.00cm for seedlings grown in 2%, 5% and 10% crude oil while the untreated (0%) had the highest plant height of mean value 22.00cm. The observed reduction in the heights of maize plant subjected to higher doses of crude oil confirmed time findings of Rowell (1977) who reported that growth retardation is possible with oil treatment due to insufficient aeration caused by displacement of air from pore spaces. It is also in line with the results of Agbogigi et al, (2012) and Oyin and Kassim, (2006) who reported that plant height reduced with increase in crude oil treatment. This result reveals that treatment of soil with crude oil significantly reduce the plant height of maize compared to those in untreated soil.

NUMBER OF LEAVES

A 3 weeks after planting there was significant differences between treatment level of 2%, 5%, 10% W/W with mean values of 2.67 and that of the untreated (0%) with the mean values of 3.67. (fig.2). Also, at 6 weeks after planting, number of leaves with significance difference were recorded for seedlings grown in 2%, 5% and 10% with mean values of 5.00, 4.00 and 3.33 when compared to seedlings grown on untreated (0%) having a mean value of 6.00. This result confirms the findings of Agbogidi et al, (2012) and Oyim and Kassim (2006) who reported that number of leaves of maize reduced with increase in crude oil. This result reveals that treatment of soil with crude oil significantly reduce the number of leaves of maize when compared to those grown in untreated soil.

Stem Girth

At 3 weeks after planting, stem girth treated with 2%, 5%, 10% were significantly different from each other. Untreated (0%) has 1.33cm while 2%, 5% and 10% had 1.33cm, 1.00cm and 0.83cm (fig 3). At 6weeks after planting, mean value of stem girth of 2% W/W crude oil treatment were at the same level of significance with mean value of 2.00cm and 1.17cm for 5% and 10%. The mean value or control 0% was 2.50cm. This result indicates that the plant were dehydrated indicating water deficiency due to increase in soil toxic levels. This result is in line with Odu (1981) who reported that adverse effects of oil on soil is due to certain conditions which makes nutrients for plant growth unavailable to plant. This may also be due to the difficulties in the absorption of water and nutrients by roots as well as toxicity of the components. This result indicates that treatment of soil with crude oil significantly reduced the stem girth of maize compared to plant grown in controlled soil.

Leaf Area

3weeks after planting , leaf area of maize was significantly ($P<0.05$) affected by treatment with 2% crude oil treatment with mean value of 83.34^3, 5% with mean value of $44.34cm^3$ and 10% with mean value of 34.34^3cm when compared to seedlings grown in untreated (0%) with mean value of $96.34cm^3$ (fig. 4). At 6weeks after planting, leaf area was significantly ($P< 0.05$) affected by treatment with 10% having the lowest mean value of $39.00cm^{3,}$ 5% having $49.00cm^3$, 2% having $88.00cm^3$ and the untreated (0%) having mean value of $101.25cm^3$. The observed reduction in the leaf area at higher levels of treatment may be attributed to the fact that crude oil treatment to soil created conditions that limited water supply to the plant. This is in line with the findings of Cutler et al (1987) who reported that water stress limit leaf development and also the reduction and depression in leaf area of maize plant grown in the higher level of oil probably led to a reduction in photosynthesis as the surface of the leaves were reduced.

Table 4: Effect of crude oil treatment on some growth parameters of maize

Crude Oil	No. of Leaves	Leaf Area	Plant height	Stem Girth
		3weeks		
0%	3.67^{a}	96.34^{a}	18.00^{a}	1.33^{a}
2%	2.67^{b}	83.34^{a}	15.00^{bc}	1.33^{aa}
5%	2.67^{b}	44.34^{a}	11.00^{bc}	1.00^{ab}
10%	2.67^{b}	34.34^{c}	8.00^{c}	0.83^{b}
$LSD_{(0.05)}$	1.08	46.15	6.39	0.82
		6 weeks		
0%	6.00^{a}	101.254^{a}	22.00^{a}	2.50^{a}
2%	5.00^{b}	88.00^{ab}	19.00^{ab}	2.00^{a}
5%	4.00^{c}	49.00^{bc}	15.00^{bc}	1.17^{b}
10%	3.33^{d}	39.00^{c}	4.00^{c}	4.00^{b}
$LSD_{(0.05)}$	0.54	46.11	6.39	0.77

abc means – on the same row with different superscript are significantly different crude oil level (%).

Proximate composition of maize 28 days after planting

Proximate composition of Zea Mays are represented in Table 4.7. The result indicated that crude protein was higher in 0% (2.60) followed by 2% (2.57), 5%(2.54) and 10% was the least (2.51). Fat was higher in 0% (2..18), followed by 2% (2.16), 5% (2.10) and 10% was the least (2.08). Ash followed the same trend 0% having the highest (0.59), followed by 2% (0.57), 5% (0.54) and 10% having the least (0.50). Moisture content was higher in 0% (8.98), followed by 2% (8.96), 5% (8.90) and 10% having the least moisture content (8.81). Carbohydrate was higher in 0% (85.63), followed by 2% (85.43), 5% (85.43) and 10% was the least (84.03).

CONCLUSION

This study was carried out to evaluate the effect of simulated crude oil pollution on soil characteristics and performance of maize (Zea mays L.). Result showed that the performance of Zea mays in terms of plant height, number of leaves, stem girth, and leaf area decreased with increased in crude oil treatment, thereby meaning that the pollution of soil with crude oil significantly reduced the growth of Zea mays compared with those of the Zea mays grown in the untreated soil (control).

RECOMMENDATION

Crude oil affected soil requires adequate remediation for them to be useful for crop production. Bioremediation which is the process of cleaning up contaminated soil is encouraged and has different approaches which included the application of organic and inorganic fertilizer would help to supply deficient nutrients to enhance soil fertility.

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