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Effect of spent engine oil contaminated soil on *Arachis hypogea* (L.), *Zea mays* (L.) and *Vigna unguiculata* (L.) Walp.

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ABSTRACT

The effect of spent engine oil contaminated soil on the germination and seedling growth of *Zea mays*, *Arachis hypogea* and *Vigna unguiculata* was investigated in the screen house of Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The research work was done using Complete Randomized Design (CRD) replicated three times. Sixty-three perforated planting buckets were filled with 5 kg of soil. Treatment was applied one week before planting of the seeds. The planting buckets filled with soil were contaminated with spent engine oil at volumes of 0, 50, 100, 150, 200 and 250 ml; while the non-contaminated soil served as the Control experiment. The experiment lasted for 12 weeks. Data obtained were analyzed using Genstat Discovery (4th Edition) and least significant difference (LSD) at p<0.05. The results obtained reveal that germination percentage, days to germination and rate of germination and seedling growth were significantly (P<0.05) affected by the spent engine oil contamination. The results of the study indicates that *A. hypogea* has more potential to be utilized for phytoremediation of spent engine oil contaminated soil than *Z. mays* and *V. unguiculata*.

INTRODUCTION

Different petroleum products are common soil contaminants and often contained hazardous chemicals especially the polycyclic aromatic hydrocarbon (Sharifi et al., 2007). There are relatively large amounts of hydrocarbons in used oil including the highly toxic polycyclic aromatic hydrocarbons (Okonokhua et al., 2007). Oil spills in Niger Delta region of Nigeria and the indiscriminate disposal of spent engine oil into water drains and vacant plots by auto mobile mechanics have been found to be hazardous to both plants and animals (Anoliefo et al., 2001). Spent engine oil is waste lubricating oil collected from automobile workshops, garages and industrial sources like hydraulics oil, turbine oil, process oil and metal working fluids (Olugboji et al., 2008). Spent engine oils are mixtures of different chemicals including petroleum hydrocarbons, chlorinated biphenyls, chlorodibenzofuran, lubricant additives, decomposition products and heavy metal that are from engine parts as they wear away (Wang et al., 2000). When oil is applied to a soil sample, microbiological components are usually negatively affected (Benka-Coker and Ekundayo, 1995). Ekundayo and Obuekwe (1997) and Agbogidi and Ejemete (2005) observed that oil in soil have deleterious effect on the biological, chemical and physical properties of the soil depending on the dose, type of oil and other factors.

Phytoremediation is a new plant based technology that is applied to organic and inorganic contaminated soil, water and sediments all over the water (Nwoko et al., 2007). Phytoremediation has shown good performance in bioremediation of crude oil contaminated soil (Issoufi et

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al., 2006; Stephen and Ijah, 2011). Although, some research works have been conducted on the effects of spent engine oil on the germination and seedling growth of some economic crops (Ismail et al., 2014; Agbogidi and Ilondu, 2013; Bona et al., 2011; Njoku et al., 2009; Ogbo 2009; Kekere et al., 2011).

Maize (*Zea mays*) is a plant belonging to the family of grasses (Poaceae). It is cultivated globally, being one of the most important cereal crops worldwide. Maize is not only an important human nutrient but a basic element of animal feed and raw material for manufacture of industrial products. In Nigeria, maize is a major food and an industrial crop grown both commercially and at subsistence level by most farmers (Miracle, 1996; Obi, 1991).

Cowpea (*Vigna uniguculata*) is an annual legume and it is a warm season crop, well adapted to many areas of humid tropics and temperate zone. It has different types which are often categorized as erect, semi erect and prostrate or climbing. Growth habit ranges from indeterminate to fairly indeterminate. Cowpea is generally tap rooted; it tolerates heat and dry conditions, but is intolerant to frost (Agbogidi and Egbo, 2012).

Groundnut (*Arachis hypogea)* is an important legume crop which forms a source of cheap food on the table of the average Nigerian. It belong to the family Fabaceae and is a native to regions like South America, Mexico and Central America (FAO, 2002). It is one of the world's principal oilseed crops (Mukhter et al., 2009). Groundnut kernels are consumed directly as raw, roasted or boiled kernels and oil extracted from the kernel is used as culinary oil. The nuts are also used as animal feed and industrial raw materials (oil, cake and fertilizer). Both domestic and foreign trade multiple use groundnut which makes it an excellent crop for developing and developed countries' commerce (Mukhter et al., 2009). Groundnut is rich in vitamins, contains at least 13 different types of vitamins that include Vitamins A, B, C and E together with 26 essential minerals like Calcium, Zinc, Iron, Boron, Potassium, Phosphorous, M.anganese, Magnesium, Copper, Fat, Sodium, Water, Protein, Carbohydrate and Fiber (Iwo and Obok, 2008).

Therefore, the aim of these trials is to find out the phytoremediation ability of the three crops studied and compare their abilities.

MATERIALS AND METHODS

Top soil samples were collected from Michael Okpara University of Agriculture, Umudike, Abia State. The seeds were brought from Seed Council, Umudike. Spent engine oil was collected from a pool of mechanical workshops in Umuahia, Abia State, Nigeria. The seeds were subjected to viability test using flotation techniques. Sandy loamy soil samples were placed inside perforated buckets. The volumes of spent engine oil used were 0, 50, 100, 150, 200 and 250 ml. Spent engine oil was added to the perforated buckets containing the soil samples. The contaminated soil samples were watered for one week to enable proper absorption of the water and the contaminants by the soil. The seeds were planted after one week of watering the soil samples. The experimental design was complete randomized design (CRD) replicated three times.

The set up was monitored for 12 weeks after planting while parameters were measured fortnightly with effect from the second week after planting (WAP).

Determination of germination percentage

Germination percentage was determined using the method of Agbogidi (2010):

$$\frac{\text{Number of seedlings that sprouted}}{\text{Number of seeds planted}} \times 100$$

Determination of days to germination

Days to germination was determined by using the method of Marli and Santana (2006). Days to germination as mean length of incubation time. It is a measurement of the average length required for maximum germination of a seed weight and expressed in terms of the unit used in making germination counts (hour or days).

Determination of rate of germination

The germination rate was calculated at the coefficient of velocity of germination density as:

$$CVG = \bar{v} = \frac{CV}{100} = \frac{1}{\bar{t}}$$

where, $\bar{v}$=mean germination rate; $\bar{t}$=mean germination time.

Seedling growth

Plant height was measured using meter-rule to measure the height of the plant from the shoot to tip at 2 weeks interval. Numbers of leaves were taken by counting the number of leaves at 2 weeks interval. Leaf area (cm^2) was determined by measuring the leaf with a graph for the maximum length and breadth of the leaf multiplying by a correction factor 0.75. The plant biomass was measured by the fresh weight of the sample subtracted from the dry weight.

Statistical analysis

Data obtained were subjected to analysis of variance using Genstat Discovery, 4th Edition (Genstat, 2007) and significant different were determined using least significant differences (LSD) at 5% level.

RESULTS

The germination percentage results obtained show a significant difference (P<0.05) between the treatment compare with the control on the three crops studied. *A. hypogea* and *Z. mays* had a better germination percentage than *Vigna unguiculata* (P<0.05). There was no germination in the 250 ml concentration except in *A. hypogea* (Table 1).

There was reduction in the days of germination as the concentration of spent engine oil increased in the soil samples compared to the control and this was statistically significant at P<0.05. Among the treatments, *A. hypogea* had lesser days to germination than *Z. mays* and *V. unguiculata* (Table 2).

Rate of germination results had a high significant difference (P<0.05) between the treatments (Table 3). Plant height showed a high significant difference between the treatment at P<0.05 (Table 4). As the toxicity of the soil samples increase, there was reduction in the plants' height compared to the Control experiment.

The number of leaves of the three crops in response to the contaminants were significant at P<0.05 (Table 5). *Z. mays* had more leaves compared to *A. hypogea* and *V. uniguiculata*.

The results of leaf area of the crops studied shows a significant difference at P<0.05 (Table 6). *A. hypogea*, *Z. mays* and *V. uniguiculata* leaf area reduced as the concentration of the spent engine oil on the soil increased.

The plant biomass of the crops displayed a high significant difference at P<0.05 (Table 7). The plant biomass reduced as the toxicity of spent engine oil increased in the soil.

DISCUSSION

The results of germination percentage, days to germination and rate of germination of *A. hypogea*, *Z. mays* and *V. unguiculata* in spent engine oil contaminated soil samples show that as the concentration of the contaminant increased the germination percentage, days to germination and rate of germination decreased. There was a significant difference among the treatment compared with the control (P<0.05). This could be as a result of volatile fraction of oil which has high wetting capacity and penetrating power; it enters the seed coat and kills the embryo. In addition, as oil contaminated soil samples become compact, it leads to poor wetting ability and increase in the amount of toxic substances which may result in decreased in germination (Srujana and Anisa, 2010; Osuagwu and Nwofia, 2014; Osuagwu and Iwuoha, 2015). Ogbo (2009) reported that effects of diesel oil on plant are species and variety dependent. The herbicidal properties of oil on plant have been reported (Agbogidi and Nweke, 2005; Adam and Duncan, 2002). This is in agreement with the trials of the three crops. The film of spent engine oil around the seeds may have acted as a physical barrier, preventing or reducing both water and oxygen entering the seeds. This would stop the germination response (Amakir and Onofeghara, 1984; Zarinkamor et al., 2013).

The spent engine oil contaminated soil samples' effects on plant height, number of leaves, leaf area, and biomass of the crops studied showed that as the dose of oil increased, the vegetative parameter reduced. Statistical analysis of the vegetative growth showed that there is significant difference in all the vegetative parameter studied. Spent engine oil contaminated soil effect on plant height showed a remarkable response compared to the Control experiment. Agbogidi and Eruotor (2012) stated that spent engine oil affected plant height, number of leaves, leaf area and biomass of *Jatropha curcas* seedling and it was concentration dependent. As a result of reduced water availability in the soil which is caused by spent engine oil on soil, thus plant height of *Corchorus olitorus* L. (Tilicaceae) were affected (Adenipekun et al., 2008). Bona et al. (2011) stated that spent engine oil affected plant height of *Schinus terebinthifolius* Raddi and it decreased over time. The results of this experiment agrees with the Bona et al. (2011) findings.

The response of leaf area to the contaminated soil samples with spent engine oil is dose dependent but at lower concentration, the plants responded positively which agrees with the work of Vwioko and Fashemi (2005).

The presence of spent engine oil on the soil-plant micro environment affects soil chemistry wherein nutrient release and uptake as well as amount of water get reduced (Nwoko et al., 2007; Odjegba and Sadiq, 2002). Vegetative growth reduction and low biomass would be attributed to the total effect of oil on the stomata number per unit area of the leaf which resulted to decrease in the photosynthetic products (Agbogidi and Ilondu, 2013).

Olayinka and Arinde (2012) stated that as the toxicity level of spent engine oil contaminated soil increases, its negative effect on the leaf area of *A. hypogea* L. also increase. The work is also in agreement with that of Agbogidi and Ilondu (2013) who stated that spent engine oil inhibited the leaf area of *Moringa olerifera* (Lam).

The number of leaves of the crops experimented with was adversely affected by spent engine oil contaminated soil samples. Adedokun and Ataga (2007) also observed

Table 1. Effect of spent engine oil on germination percentage of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

	mL					
Crop plant	**Control**	**50**	**100**	**150**	**200**	**250**
A. hypogea	8.43±0.60^{a}	4.47±0.24^{b}	1.60±0.39^{c}	1.27±0.47^{d}	0.13±0.23^{d}	0.44±0.77^{cd}
Z. mays	8.84±2.24^{a}	6.90±1.90^{a}	1.47±0.52^{b}	0.56±0.49^{b}	0.40±0.70^{b}	0.00±0.00^{b}
V. unguiculata	3.67±1.38^{d}	1.22±0.44^{b}	0.00±0.00^{c}	0.00±0.00^{c}	0.27±0.47^{bc}	0.00±0.00^{c}

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 2. Effect of spent engine oil on days of germination of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

Crop plants	mL					
	Control	**50**	**100**	**150**	**200**	**250**
A. hypogea	23.92.±0.01^{a}	9.07±0.00^{b}	4.21±0.01^{c}	3.78.±0.01^{d}	0.94±0.00^{f}	0.85±0.00^{f}
Z. mays	30.14±0.00^{a}	18.33±0.57^{b}	4.23±0.04^{c}	2.53±0.06^{d}	0.64±0.00^{c}	0.00±0.00^{f}
V.unguiculata	11.78±0.01^{a}	3.86±0.02^{b}	0.00±0.00^{c}	0.00±0.00^{d}	0.30±0.39^{c}	0.00±0.00^{c}

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 3. Effect of spent oil on the rate of germination of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

Crop plants	mL					
	Control	**50**	**100**	**150**	**200**	**250**
A. hypogea	2391.66±0.57^{a}	1250.33±0.57^{b}	492.33±0.57^{c}	3.71.33±0.47^{d}	14.50±0.57^{f}	1.35.33±0.57^{c}
Z. mays	3107.33±0.57^{a}	185.33±0.57^{c}	435.33±0.57^{b}	171.33±0.57^{d}	114.33±0.57^{c}	0.00±0.00^{f}
V. unguiculata	1078.33±0.57^{a}	350.33±0.57^{b}	0.00±0.00^{d}	0.00±0.00^{d}	85.33±0.57^{c}	0.00±0.00^{d}

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 4. Effects of spent engine oil on plant height (cm^2) of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

Crop plants	mL					
	Control	**50**	**100**	**150**	**200**	**250**
A. hypogea	27.83±0.76^{a}	20.33±3.68^{c}	25.33±1.25^{ab}	22.00±3.27^{bc}	18.66±2.88^{c}	17.33±1.60^{c}
Z. mays	85.00±5.89^{ab}	82.83±8.60^{ab}	95.00±10.50^{a}	49.00±42.46^{b}	43.50±34.36^{bc}	4.00±6.92^{c}
V. unguiculata	44.66±9.45^{a}	27.33±26.10^{ab}	11.30±14.31^{b}	18.00±7.76^{ab}	13.16±11.85^{b}	11.66±10.10^{b}

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 5. Effect of spent engine oil on number of leaves of *A. hypogea*, *Z. mays* and *V.unguiculata* at different levels of contamination.

Crop plants	mL					
	Control	**50**	**100**	**150**	**200**	**250**
A. hypogea	487.33±30.61^{a}	298.67±303.00^{b}	216.00±66.55^{b}	211.33±93.72^{b}	82.18±32.18^{b}	56.67±38.60^{b}
Z. mays	35.67±1.52^{a}	35.00±6.00^{a}	15.33±5.50^{b}	9.67±8.73^{bc}	6.33±1.30^{bc}	1.00±1.73^{c}
V. unguiculata	91.67±22.18^{a}	66.00±57.23^{ab}	28.00±48.50^{ab}	33.67±25.54^{ab}	21.67±26.36^{b}	46.00±8.67^{ab}

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 6. Effects of spent engine oil contaminated soil on leaf area (cm^2) of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

Crop plants	mL					
	Control	50	100	150	200	250
A. hypogea	1.43±0.41[b]	0.87±0.48[b]	2.89±1.76[a]	0.94±0.33[b]	0.92±0.4[b]	1.29±1.02[b]
Z. mays	319.33±0.02[a]	219.60±0.00[b]	187.50±0.00[c]	73.1200±0.00[d]	12.00±.000[e]	4.50±0.00[f]
V. unguiculata	8.40±2.20[a]	6.25±5.44 [a]	2.50±4.32 [a]	2.56±2.40 [a]	3.88±3.40 [a]	2.08±1.97[a]

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

Table 7. Effects of spent engine oil contaminated soil on the biomass (G) of *A. hypogea*, *Z. mays* and *V. unguiculata* at different levels of contamination.

Crops	Control	50mL	100mL	150mL	200mL	250
	mL					
A. hypogea	207.00±0.08[a]	151.56±0.46[c]	179.03±0.11[b]	125.37±0.54[d]	68.39±0.69[e]	12.77±0.02[f]
Z. mays	253.62±0.58[a]	202.43±0.05[b]	188.80±0.60[c]	97.25±0.05[d]	48.88±0.01[e]	0.76±0.02[f]
V .unguiculata	161.13±0.01[a]	155.94±0.15[b]	93.79±0.26[d]	111.45±0.65[c]	38.58±0.71[f]	55.33±0.57[e]

Values are means of three replicates ± standard deviation. Means with the same alphabets are not significantly different (P>0.05).

that soil samples treated with crude oil, automotive, gasoline oil and spent engine oil significantly affected the time of germination, percentage germination, plant height, leaf production and biomass of *V. unguiculata.* Babalola and Olusanya (2015) worked on the effect of sawdust soil amendment on plant height, number of leaves, number of branches and biomass of *Solanum esculentum* and observed that as the concentration increased, there was decrease in the number of leaves. This may be as a result of heavy metal toxicity and insufficiency in aeration of the soil sample caused by polycyclic aromatic hydrocarbons as observed by (Hazel, 2005). Wyszkowski et al. (2004) observed that hydrocarbons smearing root plants with oily substances limited transpiration and respiration by plants, reducing permeability of cell membrane and upsetting metabolic processes which leads to change in the chemical composition and finally toxic effects of the hydrocarbon on plants.

Sharifi et al. (2007) observed that germination, plant height and biomass of all the species were significantly ($P<0.05$) different when compared to their Control and their performance were dose dependent on the contaminated soil. Nwoko et al. (2007) observed that plant height, number of leaves and biomass of *Phaseolous vulgaris* were significantly affected by spent engine oil contaminated soil.

A. hypogea and *V. unguiculata* performed better than *Z. mays* in this study as a result of their ability to fix nitrogen and produce their own food as a leguminous plant (Nwoko et al., 2007).

In conclusion, the study demonstrated that spent engine oil contaminated soil samples has the ability to reduce the germination and seedling growth of *Z. mays*, *A. hypogea* and *V. unguiculata*. *A. hypogea* showed some level of tolerance to the contaminated soil sample.

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