SPENT ENGINE OIL CONTAMINATION OF AN ULTISOL IN SOUTHEASTERN NIGERIA: COMPARATIVE EFFECTS ON TWO CROP SPECIES

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ABSTRACT

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Toxicity from spent engine oil contamination is a prevalent problem in Nigeria. Therefore a field investigation was carried out at the Teaching and Research Farm of the University of Nigeria, Nsukka, Nigeria to determine the effect of spent engine oil contaminated soil on growth and yield parameters of maize and cowpea. Post contamination sampling indicated that spent engine oil significantly (P < 0.05) increased total hydrocarbon content and bulk density of spent engine oil contaminated soil by 25411 mg/kg and 1.50 g cm\textsuperscript{-3} respectively whereas soil water loss between 2 - 10 days after saturation was highest (40 %) in the first three months in 3 % spent engine oil contaminated. Germination was 32 % lower in maize than cowpea while spent engine oil had 29 folds more detrimental effects on leaf expansion of maize compared to cowpea. It was also observed that the dry matter content and grain yield of maize was more than 3 times and 2.5 times respectively, reduced compared to that of cowpea. It was concluded that spent engine oil had detrimental effects on soil physical properties and the test crops, however maize showed higher susceptibility compared to cowpea.

Keywords: Spent engine oil, soil contamination, soil properties, maize, cowpea, Ultisol

INTRODUCTION

The economy of Nigeria is largely hinged on revenue from petroleum and petro-chemicals. Spent lubricating oil is one of the petro-chemicals reported to be a major and most common soil contaminant in Nigeria. Obtained after servicing and subsequent draining of used oil from automobiles and generator engines, it contains potentially toxic polycyclic aromatic hydrocarbons (Sharifi, \textit{et. al.}, 2007) and heavy metals. However, the proportion and type of these heavy metals depend on the process generating the waste. It is indiscriminately disposed into gutters, water drains, open vacant plots and farms by auto technicians and allied artisans with workshops on the road sides and open places (Anoliefo and Vwioko, 2001). The consequences are the pollution of water bodies, contamination of ground water and toxicity to animals and plants.

There are several types of toxicity studies involving plant processes. According to Fletcher (1991), the tests with plants can be used in 5 different categories: biotransformation, food chain uptake, sentinel, surrogate, and phytotoxicity. Among these tests, the phytotoxicity is receiving more attention in recent years. Some species recommended for toxicity tests by the United States Environmental Protection Agency (USEPA) and Federal Department of Agriculture are rice (\textit{Oryza sativa}); soybean (\textit{Glycine max}); maize (\textit{Zea mays}); tomato (\textit{Lycopersicon esculentum}); and bean (\textit{Phaseolus aureus}; \textit{Phaseolus vulgaris}); among others (Fletcher, 1991). This however does not indicate that other crops peculiar to impact areas cannot be used as test plants. Cowpea (\textit{Vigna unguiculata} \textit{L.}) and maize (\textit{Zea mays} \textit{L.}) are principal crops in the various farming systems practiced in Nigeria. Cowpea belongs to the family fabaceae and sub-family faboideae. It is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics (Anoliefo et al., 2006; Ogbo,2009). Cowpea (\textit{Vigna unguiculata} \textit{L.}) is a popular leguminous food in Nigeria (Adelaja, 2000; Adaji \textit{et. al.}, 2007). It is cultivated extensively in West Africa and it is the principal source of dietary protein in Nigeria (Brantley, 1992) from the swampy rain forest of the Niger Delta to the sparse savannah grassland of northern Nigeria. It is available throughout the year either as vegetable or as pulse (Singh and Rachie, 1985; Asumugha, 2002; Olapade \textit{et. al.}, 2002). Islam \textit{et. al.}, (2006) noted that cowpea is more tolerant to drought, water logging, infertile soils and acid stress than common beans. Tiwah, \textit{et. al.}, (1997) however, reported that moisture stress can reduce productivity considerably during the period from emergence to first flower. The authors also found that nodulation was reduced by water stress.

The genus \textit{Zea}, with cultigens \textit{Zea mays} as the only species, belongs to the tribe \textit{Maydeae}. According to Nafziger (2014) maize (\textit{Zea mays} \textit{L.}) is the most important and most widely distributed cereal in the world after wheat and rice. It is used for three main purposes: as a staple food crop for human consumption, as feed for livestock and as raw material for many industrial uses, including bio-fuel production. In sub-humid and semi-arid regions in Africa
(especially in Nigeria) and Latin America, maize is consumed green (boiled and roasted), boiled (dry) with beans and ground into flour, cooked and eaten as thick porridge. Maize does well on a wide range of soils, but performs best on well drained, well aerated, deep, warm loams and silt loams containing adequate organic matter and well supplied with available nutrients (Nafziger, 2014). The author also reported that flowering time is influenced by photo period and temperature while optimum germination temperature ranges between 18 - 21°C and below 13°C it is greatly reduced, then fails below 10°C. Though maize is water efficient, the objective to obtain high yields require a considerable amount of water. Seasonal water use is about 500 to 600 mm in temperate areas, and up to 900mm or more (depending on evaporative demand) under irrigation in dry climates (Nafziger, 2014). Under rain fed conditions, which is the most common production system, plant water is supplied by seasonal rainfall and stored soil water. Nafziger (2014) further noted that water uptake gradually increases from the germination into the vegetative growth stage and reaches a peak by the time the crop canopy is complete; and more in particular from just before until just after the pollination period. The author also observed that water shortages during this period may prevent successful flowering and fertilization, and thereby greatly reduce grain yield. High productivity means high demands for water. Measured water use efficiency for maize is as high as 2.5kg grain per m³ of water used and at full canopy, water use rates may be 6 to 8 mm per day (Nafziger, 2014). The seasonal water use by a 10 tonne maize crop is typically about 500 mm and if high maize yields are to be anticipated, this minimum amount of water should be assured (Nafziger, 2014). Water supply may be optimum yet not available for crop use due to prevailing adverse soil conditions. Spent engine oil contamination of soils has been found to give rise to such adverse conditions. According to West et. al., (1992) a reduction in porosity from 90 to 30% resulted from the formation of structural crusts due to soil contamination with spent engine oil. Associated with the porosity decrease by structural crust was a reduction in the mean size of pores. McGill (1976) observed that oil occupied the macrospores and coated macro aggregates thereby reducing the water film thickness around macro aggregates and retarded the movement of water into soil aggregates. Rasiah et. al., (1990) in the same vein, observed that oil interacted with clay surfaces to form hydrophobic micro-aggregates. Kirk et. al (2005) further stated that because of the hydrophobic nature of the contaminant, water and water-soluble nutrients are often limited in spent engine oil contaminated soils. Anoliefo and Vwioko (1995) observed that oil in soil created unsatisfactory conditions for plant growth, probably due to insufficient aeration of the soil. They further reported that this condition was caused by the displacement of air from pore spaces by oil, and an increase in the demand for oxygen brought about by activities of oil-decomposing micro-organisms. Depletion in the nutrient status (nitrogen and phosphorous) has been reported in spent engine oil-contaminated soils (Atlas and Bartha, 1993). Crop response to these adverse soil conditions are likely to vary as a result of differences in physiological and morphological adaptations.

In this vein, Anoliefo and Vwioko (1995) observed that spent engine oil contamination effect was more pronounced on Lycopersicon esculenta than on Capsicum annum. Anoliefo and Edegbai (2000) reported that Solanum melongena was more tolerant of spent lubricating oil than S. incanum. Similarly Sharifi et al. (2007) noted that Medicago truncatula was the most tolerant plant species among the six species he examined. There is however paucity of information comparing the response of cowpea to that of maize under this type of soil contamination. Information of this nature would prove useful in the selection and recommendation of tolerant crop species to farmers in oil spill prone Niger delta and areas beyond, where spent engine oil contamination is prevalent. This therefore, forms the basis of this study in an Ultisol in South-eastern Nigeria. The specific objectives were to assess the effect of spent engine oil contamination on some soil chemical and physical properties, and compare the rate of change in growth and yield parameters of maize and cowpea as affected by varying doses of spent engine oil so as to determine the more tolerant of the two crops.

MATERIALS AND METHODS

Site description

This experiment was conducted in 2007, on the University of Nigeria, Nsukka Teaching and Research Farm, located by latitude 06°52’N and longitude 07°24’E and at an elevation of 400m above sea level. The location is within the forest transition vegetation zone and has an average annual precipitation of about 1700mm (FORMECU, 1998). Rainfall during the wet season is bi-modally distributed, with peaks in July and September and a short dry spell around mid- August. The soil is classified as an Ultisol (Oxic Paleustult) with an isohyperthermic temperature regime. It is formed over false bedded sandstone parent materials and belongs to the Nkpologu series (Nwadialo, 1989). Ahamefule and Peter (2014) reported that this soil is sandy-loam textured and acid in reaction. Some characteristics of its surface soil are described in Table 1.

Experimental design and layout

The experiment was laid out in a Randomized complete Block Design (RCBD) with four (4) levels of spent engine oil contamination replicated three (3) times giving a total of 12 plots. The four (4) levels of spent engine
oil contamination were 0, 1, 2, and 3 % equivalent to 0, 10, 000, 20,000 and 30,000 mg kg\(^{-1}\) of soil respectively. The experiment covered a land area of 15.125 m\(^2\) (5.50 m x 2.75 m)

### Field preparations

Soil samples were collected in a grid of 2 x 1 m, bulked and a composite sample taken for laboratory analyses to determine the initial physical and chemical properties of the site. Glyphosate, a post emergence herbicide (a.i isopropylamine) and butachlor, a pre-emergence herbicide (a.i.2-chloro-2, 6- diethyl – N (butoxy methyl) acetanilide) were used to control weeds. The plots were manually tilled and the spent auto engine oil applied two weeks before planting to allow for adequate percolation. The test crops comprised of cowpea (Vigna unguiculata L. Wulp, var 355), and maize (Zea mays. Oba super II). They were grown for one planting seasons (2007) spanning from May to August. The cowpea was the erect and low branching type. Each plot contained 20 plants (10 stands of maize and cowpea each) at one plant per stand in two rows (a row each for maize and cowpea) giving a plant population of 80, 000 plants ha\(^{-1}\). Sowing was done manually at the rate of two seeds per hole, to depth of 2.5 cm and spacing of 50 cm x 25 cm, and thinned down to one plant per stand after emergence.

#### Data collection

Germination count was taken 8 days after planting and percent germination calculated thus:

\[
\text{Percent germination} = \frac{\text{number of germinated seeds}}{\text{number of seed sown}} \times 100
\]

Maize leaf area was determined at tasseling whereas that of cowpea was at flowering using an area metre (machine) connected to a monitor that displays the total leaf area and the number of leaves per sample. Dry matter was also determined at tasseling and flowering for maize and cowpea respectively, by oven drying plant samples to constant weight and the final weight determined as the dry matter content. Harvesting took place when the maize and cowpea had sufficiently dried in all treatments. The dry maize cobs and dry cowpea pods were shelled, and the grain weighed at 14 % moisture content to obtain the yield.

#### Laboratory studies

Bulk and core soil samples for laboratory analyses were collected from 0 – 20 cm depths at 0 months (before treatment) and 3, 6, 12 months after contamination. Total hydrocarbon content of the contaminated soils was determined gravimetrically by toluene extraction (cold extraction) method as described by Odu et al., (1989). Bulk density was determined according to Blake and Hartage (1986) while total porosity was estimated from bulk density values and assumed particle density of 2.65 g/cm\(^3\). Moisture content 2 and 10 days after saturation was determined by the procedure of Gardner (1986).

#### Data analysis

All data collected were subjected to analysis of variance using SPSS version 16.0 computer statistical package while significant treatment means were separated at 5 % probability level with Fisher’s Least Significant Difference (F-LSD).

### RESULTS AND DISCUSSION

Initial soil properties of the experimental site

The initial characteristics of the top soil of the experimental site revealed that the texture of the experimental soil was sandy-loam whereas the organic carbon content, pH, P, and CEC were generally low to very low. This is typical of degraded Ultisols (Table 1).

#### Changes in soil total hydrocarbon content (THC) following spent engine oil contamination

Increase in the dose of spent engine oil contamination expectedly increased the total hydrocarbon content of the soil (Table 2). The contamination of soil with 1, 2 and 3 % spent engine oil increased total hydrocarbon content from control value of 825 mg kg\(^{-1}\) to 7449 mg kg\(^{-1}\), 16103 mg kg\(^{-1}\) and 25411 mg kg\(^{-1}\) respectively, in the first 3 months. This revealed that about 75 – 85 % of the contaminant was still present in the treated soil within this period, which also coincides with the growing period of the test crops. This amount of residual THC especially at the higher rates (2 and 3 %) can significantly retard physiological processes in some plants (Vwioko and Fashemi, 2005). The soil THC values however, reduced gradually over the next 9 months, reaching a minimum of 4701 mg kg\(^{-1}\), 12120 mg kg\(^{-1}\) and 19987 mg kg\(^{-1}\) in plots under 1, 2 and 3 % spent engine oil treatments respectively. The result generally indicated that THC of treated soils followed a 3 > 2 > 1 > 0 % trend. The reduction of spent engine oil in the contaminated soils with time is thought to be due to microbial degradation and deep percolation beyond the sampling zone. Avidano et al., (2005) observed that Pseudomonas and Bacillus micro-organisms were prevalent in petroleum contaminated sites, whereas dramatic reduction occurred in the total microbial community due to the additions of petroleum waste sludge. Petroleum hydrocarbon utilizers can tolerate oil contaminated environments because they possess the capacity to utilize oil as energy source (Jelena et. al., 1990). On the other hand Katsivela et. al., (2005) reported that petroleum waste sludge adversely affected the microbial population by
depleting essential inorganic nutrients and growth factors and lowering the pH immediately around negatively charged soil surfaces.

**Effect of oil contamination on soil bulk density**

Table 3 shows that the bulk density of spent engine oil contaminated soils increased significantly (P < 0.05) with increase in the rate of oil treatment. Within the growing period of the test crops (first 3 months) the bulk density of soils under 1, 2 and 3 % spent engine oil treatments were 1.54, 1.59 and 1.65 g cm\(^{-3}\) respectively. Bulk density as observed in 3 % oil contaminated plots can significantly reduce porosity, infiltration rate and emergence. According to Grossman and Reinsch (2002) soils with bulk density ranging from 1.6 – 1.7 g cm\(^{-3}\) are will show massive structures and less porosity which will hinder the movement of water down the profile.

Table 1: Some properties of the surface soil at the start of the experiment

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay (%)</td>
<td>18</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>13</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>69</td>
</tr>
<tr>
<td>Bulk density (g cm(^{-3}))</td>
<td>1.50</td>
</tr>
<tr>
<td>Saturated hydraulic conductivity (cm h(^{-1}))</td>
<td>7.49</td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.067</td>
</tr>
<tr>
<td>pH (H(_2)O)</td>
<td>4.8</td>
</tr>
<tr>
<td>CEC (cmol/kg soil)</td>
<td>4.03</td>
</tr>
<tr>
<td>Ca (cmol/kg soil)</td>
<td>2.15</td>
</tr>
<tr>
<td>Mg (cmol/kg soil)</td>
<td>0.5</td>
</tr>
<tr>
<td>K (cmol/kg soil)</td>
<td>0.1</td>
</tr>
<tr>
<td>Available P (mg kg(^{-1}))</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Table 2: Effect of spent engine oil contamination on total hydrocarbon content (mg kg\(^{-1}\)) of soil

<table>
<thead>
<tr>
<th>Oil concentration (%)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>825(^a)</td>
<td>832(^b)</td>
<td>835(^c)</td>
<td>834(^d)</td>
</tr>
<tr>
<td>1</td>
<td>825(^a)</td>
<td>7449(^c)</td>
<td>6004(^c)</td>
<td>4701(^c)</td>
</tr>
<tr>
<td>2</td>
<td>825(^a)</td>
<td>16103(^b)</td>
<td>15001(^b)</td>
<td>12120(^b)</td>
</tr>
<tr>
<td>3</td>
<td>825(^a)</td>
<td>25411(^a)</td>
<td>21085(^a)</td>
<td>19987(^a)</td>
</tr>
</tbody>
</table>

Values followed by the same letters within the same column are not significant at P \(\leq 0.05\) using Duncan’s multiple range test.

Table 3: Effect of spent engine oil contamination on soil bulk density (g cm\(^{-3}\))

<table>
<thead>
<tr>
<th>Oil concentration (%)</th>
<th>Months</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.50(^a)</td>
<td>1.50(^a)</td>
<td>1.49(^a)</td>
<td>1.50(^a)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.50(^a)</td>
<td>1.54(^c)</td>
<td>1.55(^c)</td>
<td>1.53(^c)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.50(^a)</td>
<td>1.59(^b)</td>
<td>1.61(^b)</td>
<td>1.60(^b)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.50(^a)</td>
<td>1.65(^a)</td>
<td>1.68(^a)</td>
<td>1.67(^a)</td>
<td></td>
</tr>
</tbody>
</table>

Values followed by the same letters within the same column are not significant at P \(\leq 0.05\) using Duncan’s multiple range test.

The highest soil bulk densities were observed 6 months after contamination, however the 12th month indicated a decline. Oil is thought to increase soil bulk density by reducing the frictional forces at interfaces between soil particles and with the slightest impact from rain drops and some other agents of denudation, the particles assume a more tightly parked structure; this have been reported as crusting by some researchers (Rasiah et al., 1990; West et al., 1992 and Amadi et al., 1993).

**Effect of oil contamination on soil water retention**

The moisture content of contaminated soils 2 days after saturation (which approximates field capacity) and 10 days after saturation (approximately permanent wilting point) reduced with increasing dose of spent engine oil (Table 4). The moisture contents were least in the first 3 months and increased gradually to the highest values in the 12th month following contamination. The moisture loss pattern generally indicated that in the 8-day interval between the two determinations the per cent losses increased with spent oil dose and reduced with time (month) of sampling. Per cent moisture losses in the 3rd month of sampling were 18.8, 28.6, 30.0 and 40.0% compared to 12.5, 18.8, 25.0 and 33.3% in the 12th month for spent engine oil doses of 0, 1, 2 and 3% respectively. The result
suggests that 8-days of no rainfall within the growing period of the test crops may predispose plants in plots with less than 3% oil contamination to water stress. This is evident in the 3 per cent (0.03 g g\(^{-1}\)) moisture content recorded for plots with less than 3 % oil contamination compared to 25% moisture content for an ideal soil. Oil contaminated soils may have lost more water due to the hydrophobic properties of spent engine oil which impeded the adherence of water molecules to soil particles thereby increasing the free energy of soil water; with this less energy was required for soil water loss by evaporation and percolation down the profile.

**Effect of oil contamination on maize and cowpea germination**

The response of maize and cowpea germination to spent engine oil contamination was linear with a negative slope which generally indicated that the contaminant adversely affected the physiological process of germination in both crops (Fig.1). However the slope magnitude of the best fit regression models (lines) which indicated 15.6 and 10.6 for maize and cowpea respectively, shows that germination in maize stood more than 32% higher risk of suppression compared to that in cowpea under spent oil contamination. The best fit regression models obtained from germination counts of maize and cowpea indicated that the models accounted for 84 and 87% variation in the germination of maize and cowpea seeds respectively. The predictive ability of the models as indicated by the \(R^2\) values is 3 % higher for cowpea than maize. In similar experiments Udo and Fayemi (1975) Amadi et al. (1993) and Ekundayo et al. (2001) reported that spent engine oil reduced germination by coating on seed surfaces thereby affecting physiological functions within the seed. Atuanya (1987) also reported that reduced oxygen content of the soil due to the blockage of pores in the soil and increased water stress on the seed imposed negative effects on germination. Therefore the observed variations in the germination

Table 4: Effect of spent engine oil contamination on moisture content 2 and 10 days after saturation

<table>
<thead>
<tr>
<th>Oil concentration (%)</th>
<th>Moisture loss</th>
<th>Moisture content (g g(^{-1}))</th>
<th>10 days after saturation</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 days after saturation</td>
<td>10 days after saturation</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.16(\text{a})</td>
<td>0.13(\text{a})</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.14(\text{b})</td>
<td>0.10(\text{b})</td>
<td>28.6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.10(\text{c})</td>
<td>0.07(\text{c})</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.05(\text{d})</td>
<td>0.03(\text{d})</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.16</td>
<td>0.14</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.15</td>
<td>0.12</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.10</td>
<td>0.08</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>0.04</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.16</td>
<td>0.14</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.16</td>
<td>0.13</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.12</td>
<td>0.09</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.09</td>
<td>0.06</td>
<td>33.3</td>
<td></td>
</tr>
</tbody>
</table>

Values followed by the same letters within the same column are not significant at \(P \leq 0.05\) using Duncan’s multiple range test

Fig.1: Comparative effect of spent engine oil on the germination of maize and cowpea plants

Responses of maize and cowpea test crops in this experiment may be related to morphological differences in seeds, especially testa composition and thickness. Testa composition may allow for selective fluid penetration
while higher thickness will retard fluid absorption. It is important to note that Water absorption is necessary for germination whereas absorption and/or adsorption of oil molecules by the seed will retard water entrance into the seed.

**Effect of oil contamination on leaf area of maize and cowpea**

Fig.2 shows a linear response of the leaf area of maize and cowpea crops to increasing doses of spent engine oil contamination of soil. The negative slope is an indication that the availability and/or translocation of plant nutrients may have suffered leading to decline in apical and lateral meristematic multiplication responsible for leaf expansion. This suggests that nutritional problems may have developed in the rhizosphere and/or within the plant roots due to increasing dose of spent engine oil. Depletion in soil nutrient status (nitrogen and phosphorous) has been reported by Atlas and Bartha, (1993) and Amadi et al. (1993) while Sharma et al. (1980) reported plant morphological aberration, in spent engine oil contaminated soils. However the result of this experiment which indicates a slope magnitude of 122.8 and 4.2 for maize and cowpea plants respectively shows that spent engine oil has 29-folds more detrimental effects on leaf expansion of maize compared to cowpea plant. The best fit regression models accounted for 82 and 75 % variation in the leaf area of maize and cowpea respectively, with 7 % higher predictive ability in maize compared to cowpea. The response of the test crops here agrees with Atuanya (1987) who posited that contamination of soil with petroleum and its derivative has pronounced effect on plant growth and that the extent to which plants were affected differed due to an innate genetic response of the plant system as modified by environmental influences. Similarly it is also thought that root nodule bacteria in cowpea may have modified the rhizosphere of cowpea plant thereby making it more nutritionally favourable compared to that in maize.

![Fig.2: Comparative effect of spent engine oil on the leaf area of maize and cowpea plants](image)

**Effect of oil contamination on dry matter content of maize and cowpea**

Fig.3 indicate that the dry matter response of the test crops to spent engine oil contamination was linear with negative slopes indicating that increased rates of oil contamination led to reduction in dry matter accumulation in the plants. This condition may have arisen from the declining leaf area which meant less dry matter production and deposition. The magnitude of the slope of the best fit regression models, 1.77 and 0.54 for maize and cowpea respectively show that maize was more than thrice adversely affected compared to cowpea. The $R^2$ values indicate a 21 % higher predictive ability of the model for maize compared to that for cowpea.

**Effect of oil contamination on grain yield of maize and cowpea**

The response of grain yield of the test crops followed a linear pattern with a negative slope which indicated an adverse impact of spent engine oil (Fig.4).However the slope of the response curves exhibited by the crops, 0.58 and 0.21 for maize and cowpea respectively, showed that grain yield in maize was more than 2.5 times adversely affected under the spent oil doses used in this experiment. Grain yield in cowpea may have been less affected by spent engine oil due to the comparatively higher leaf area of cowpea (Fig.2) which ensured a higher contribution of photosynthates to grain filling. The $R^2$ values for maize (76 %) showed higher predictive ability compared to that for cowpea (56 %) which is the possible contribution of spent engine oil to the decline in grain yield.

**CONCLUSION AND RECOMMENDATION**

It can be concluded from this experiment that The contamination of soil with 1– 3 % spent engine oil significantly increased its total hydrocarbon content which in turn led to a significant increase in bulk density and decreased
water retention capacity. The resultant variations in soil properties generally had more than 3.5 times adverse effects on growth and yield parameters of maize compared to that of cowpea plant. Based on the results obtained in this study it therefore recommended that farmers whose plots have been contaminated with spent engine oil (petroleum hydrocarbons) should cultivate cowpea rather than maize in the first year of impact, if the soil must run a natural recovery course.

Fig.3: Comparative effect of spent engine oil on the dry matter content of maize and cowpea plants

Fig.4: Comparative effect of spent engine oil on the grain yield of maize and cowpea plants

REFERENCES

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