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PRELIMINARY TOXICITY EVALUATION OF SOIL CONTAMINATED WITH PETROLEUM DERIVATIVES ON SOME CROP PLANTS

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ABSTRACT

The germination and growth of *Zea mays* and *Sorghum bicolor* were investigated on soils contaminated with different petroleum derivatives. This was carried out with a view to ascertaining the toxicity effects of these derivatives on the crop plants. Soil was collected from area with no previous contamination and was filled inside polythene bags. The experimental setup for each contaminant was a complete randomized design with three replicates. Each of the petroleum derivatives which include diesel oil (AGO), spent engine oil and lubricant oil each had three treatments i.e. 0 ml, 50 ml and 100 ml. The 0 ml treatment represents control where the soil was mixed with distilled water only. Five seeds of each crop plant were picked at random and sown on the soils containing the treatments and the experiments were monitored for five weeks. The germination percentage was calculated daily for seven days while the plant height and leaf areas were determined weekly. Results showed that the controls of all the crop plants had the highest percentage germination while the treatment that had 100 ml contaminations had the lowest. It was also observed, the higher the diesel oil contamination, the lower the leaf areas of *Zea mays* and *Sorghum bicolor*. In all the treatments of the crop plants, it was observed that the controls had the highest plant height compared to the 50 ml and 100 ml contaminations. All the observed differences between the controls and the levels of contaminants for each treatment were significant. This indicates that these petroleum derivatives have pronounced toxic effects on *Zea mays* and *Sorghum bicolor* particularly the 100 ml lubricant oil level treatment which exhibited a lethal effect on Sorghum bicolor.

Keywords: *Petroleum derivatives, Sorghum bicolor, Toxicity, Zea mays*

INTRODUCTION

Researches on investigations of toxicity effects of soils contaminated with petroleum derivatives on plants have received extensive attention in the last two decades (Banks *et al.*, 2005). The sources of carcinogenic and toxic soil contaminations are mainly the disposal of public wastes and used petroleum products (Zhen-Guo *et al.*, 2002). Plants used in ecotoxicological investigations are more sensitive to toxic metals during their early growth stages (Cruz *et al.*, 2013). This is because their resistance mechanisms are not yet fully developed (Liu *et al.*, 2005).

There is usually pronounced changes in biochemical and physical properties of soils polluted with petroleum compounds (Ekundayo *et al.*, 1989). Essential and non-essential elements in soils are built up whenever soils are polluted with petroleum products and are eventually translocated to all plant tissues (Vwioko *et al.*, 2006). Plants are contaminated with heavy metals as a direct consequence of heavy metal pollution in soil, water and air. It is worthy to note that Plants are rarely exposed in nature to the effect of a single heavy metal. This is because many metal ions exist mostly in mixtures in different contaminated soils and water across the world (Souza and Rauser, 2003). However, only few studies on the combine effects of a mixture of petroleum products on crop plants have been documented (Yang *et al.*, 2004; Zeid, 2001).

The objective of this study was to evaluate germination and growth of *Zea mays* and *Sorghum bicolor* in order to determine the toxicity of soils contaminated with diesel, lubricant oil and spent engine oil.

MATERIALS AND METHODS

The soil used for this study was obtained in a nursery farm of Tripple Zee farm, Lafia, Nigeria. Toxicity rates were investigated by using three different petroleum derivatives: lubricant oil, commercial diesel and spent engine oil. The lubricant oil and diesel were purchased from a petrol station in Lafia, Nigeria while the spent engine oil was collected from an automobile mechanic workshop in Lafia, Nigeria. Seeds of *Zea mays* (maize) and *Sorghum bicolor* were used as bioindicator and were subjected to various levels of the contaminants.

Soil of about 1 kg was thoroughly mixed with the contaminants and was poured inside polythene bags which were perforated in order to establish contact with potential biodegrading microorganisms naturally present in soil. The experimental design was complete randomized design (CRD) with three replicates. There were three levels of each contaminant, 0 ml, 50 ml and 100 ml. The 0 ml represents the control which was only mixed with distilled water. Five seeds of each crop plant were randomly selected and planted inside each polythene bag containing different levels of the contaminants.

The experiment was allowed to stand for five weeks at the Department of Botany, Federal University Lafia, Nigeria and the germination rate was monitored and recorded. After the first week of planting, different growth parameters such as leaf length, breadth, area and plant height were recorded weekly. The leaf area was calculated using the formula of Osei-Yeboah (1983) as follows:

Leaf area = leaf length x leaf breadth x 2.325 (correction factor).

All data were subjected to one way analysis of variance (ANOVA) used to determine the significance in the treatment means of all the growth parameters at $\alpha \leq 0.05$ using SPSS version 17. The treatment means were compared using Duncan's multiple range test.

RESULTS AND DISCUSSION

Some of the leaves of all the crop plants grown on contaminated soils showed severe yellowish colour and their growth were stunted compared to the control plants. The germination percentages in all the highest level of pollutants (100 ml) were found to be the lowest while the controls have the highest germination percentages (table 1). Also, there was no growth of *Sorghum bicolor* in the 100 ml lubricant oil contaminated soils. The highest percentage germination (93.3%) was observed in the control of *Zea mays*. According to USEPA (1996), the minimum germination rate of a plant that is not affected by contaminant is 65%. From this work, *Zea mays* and *Sorghum bicolor* have been greatly influenced by the toxicity of diesel oil, lubricant oil and spent engine oil as their germination rates in the contaminant levels were less than the 65%. Sorghum bicolor is more susceptible to lubricant oil as it could not withstand highest contaminant level (100 ml).

The leaf areas of *Zea mays* and *Sorghum bicolor* in the controls were significantly higher than the 50 ml and 100 ml diesel oil concentrations i.e. the higher the diesel oil contamination, the lower the leaf areas of *Zea mays* and *Sorghum bicolor* (table 2 and 3). A similar trend was observed in the plant heights of the two crop plants grown on the different contaminants as the control had the highest plant height at the end of the fifth week followed by the 50ml and 100 ml concentrations respectively (Fig. 1, 2 and 3). These plant heights of all the crop plants grown on different contaminants are significantly different between all the treatments ($\alpha \leq 0.05$). The reverse was observed in the leaf area of *Zea mays* grown on spent engine oil contaminated soil where the control had the significantly highest leaf area followed by the 100 ml concentration and the 50 ml had the lowest leaf area at the end of the fifth week (table 4). However, the differences in the leaf areas of the 50 ml and 100 ml treatments are not significant. Also, the leaf areas of the control of *Sorghum bicolor* and 50 ml lubricant oil contamination are significantly different with the control having the highest at the end of fifth week (table 5).

These agree with Okonokhua *et al*., (2007) who reported that spent engine oil negatively affected the growth parameters of *Zea mays* grown in the contaminated soils. In this study, the toxic effects of these petroleum derivatives on growth of *Zea mays* and *Sorghum bicolor* might be due to the availability of heavy metals to the plants as a result of the acidic environment in the soil by the increase in oil concentrations (Odjegba and Atebe, 2007; Okonokhua *et al*., 2007). Also according to Adedokun and Ataga (2007), treatment of soils with used and unused petroleum products significantly delayed the germination period, reduced germination percentage and other growth parameters of Vigna unguiculata. In addition, mixture of these petroleum derivatives as observed by Njoku *et al.,* (2009) could cause threats to the development and survival of plants. Petroleum derivatives have been known to reduce the relative growth rate of plants as a result of reduction in nitrogen availability in the soil (Agbogidi *et al*., 2007). Therefore, the reduced growth parameters observed in this study can be attributed to the low nutrient level in the polluted soils. This is further supported by Ogbo, (2009) who reported that *Arachis hypogea*, *Vigna unguiculata, Sorghum bicolor* and *Zea mays* were sensitive to diesel fuel contamination and they were also able to withstand the contamination to some degrees.

CONCLUSION

Conclusively, *Zea mays* and *Sorghum bicolor* are not tolerant to these petroleum derivatives due to the pronounced effects on their germinations and growths. This indicates that they may not be able to withstand the contaminants for a very long period and are not recommended as good candidates for remediating polluted soils.

Table 1: Germination percentages of all the crop plants grown on different contaminants after seven days

Crop Plant	Diesel Oil			Lubricant Oil			Spent Engine Oil		
	0 ml	50 ml	100 ml	0 ml	50 ml	100 ml	0 ml	50 ml	100 ml
Zea mays	86.7%	20%	6.7%	NA	NA	NA	93.3%	66.7%	46.7%
Sorghum bicolor	86.7%	26.7%	13.3%	86.67%	46.67%	0%	NA	NA	NA

NA means Not Available

Table 2: The leaf area of *Zea mays* grown on diesel oil contaminated soil

Treatment	Week1	Week2	Weekk3	Week4	Week5
0 ml	21.0a ± 1.80 cm2	37.58a ± 16.5 cm2	47.27a ± 8.11 cm2	54.25a ± 11.8 cm2	74.4a ± 22.43 cm2
50 ml	4.65b ± 2.46 cm2	14.11b ± 10.96 cm2	14.11b ± 4.17 cm2	14.18b ± 0.23 cm2	106.53b ± 25.4 cm2
100 ml	1.09c ± 1.1 cm2	7.13c ± 3.61 cm2	8.22c ± 4.13 cm2	8.91c ± 5.38 cm2	9.3c ± 5.06 cm2

Values correspond to the mean ± standard error. Significant differences among treatments within a week are followed by different letters ($\alpha \leq 0.05$).

Table 3: the leaf area of *Sorghum bicolor* grown on diesel oil contaminated soil

Treatment	Week1	Week2	Weekk3	Week4	Week5
0 ml	11.43a ± 1.07 cm2	29.37a ± 3.37 cm2	51.30a ± 4.52 cm2	74.52a ± 3.89 cm2	112.22a ± 10.87 cm2
50 ml	2.92b ± 0.46 cm2	7.83b ± 0.43 cm2	12.34b ± 1.22 cm2	19.66b ± 1.59 cm2	24.24b ± 3.42 cm2
100 ml	0.48b ± 0.27 cm2	1.21b ± 0.61 cm2	3.56b ± 1.79 cm2	5.00b ± 2.51 cm2	6.71b ± 3.37 cm2

Values correspond to the mean ± standard error. Significant differences among treatments within a week are followed by different letters ($\alpha \leq 0.05$).

Table 4: The leaf area of *Zea mays* grown on spent engine oil contaminated soil

Treatment	Week1	Week2	Weekk3	Week4	Week5
0 ml	79.51c ± 17.02 cm2	186.39c ± 24.55 cm2	242.77c ± 27.32 cm2	302.38c ± 29.02 cm2	348.57c ± 33.98 cm2
50 ml	29.37d ± 5.12 cm2	79.58d ± 11.14 cm2	99.34d ± 10.79 cm2	122.48d ± 11.74 cm2	132.86d ± 13.77 cm2
100 ml	40.96d ± 13.98 cm2	89.33d ± 18.39 cm2	112.68d ± 13.27 cm2	125.74d ± 14.09 cm2	136.80d ± 11.88 cm2

Values correspond to the mean ± standard error. Significant differences among treatments within a week are followed by different letters ($\alpha \leq 0.05$).

Table 5: The leaf area of *Sorghum bicolor* grown on lubricant oil contaminated soil

Treatment	Week1	Week2	Weekk3	Week4	Week5
0 ml	3.85e ± 0.60 cm2	14.17e ± 1.11 cm2	27.28e ± 0.31 cm2	43.01e ± 0.67 cm2	65.57e ± 0.81 cm2
50 ml	1.08f ± 0.15 cm2	3.72f ± 1.01 cm2	7.13f ± 0.67 cm2	10.37f ± 0.33 cm2	11.34f ± 1.34 cm2
100 ml	NG	NG	NG	NG	NG

NG means No Growth. Values correspond to the mean ± standard error. Significant differences among treatments within a week are followed by different letters ($\alpha \leq 0.05$).

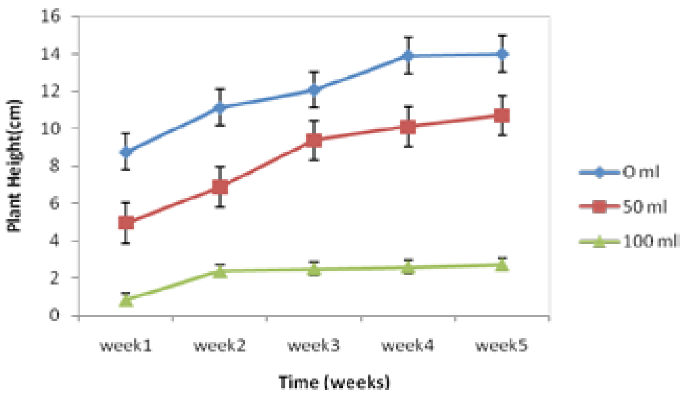

Fig 1: Plant height of *Zea mays* grown on diesel contaminated soil

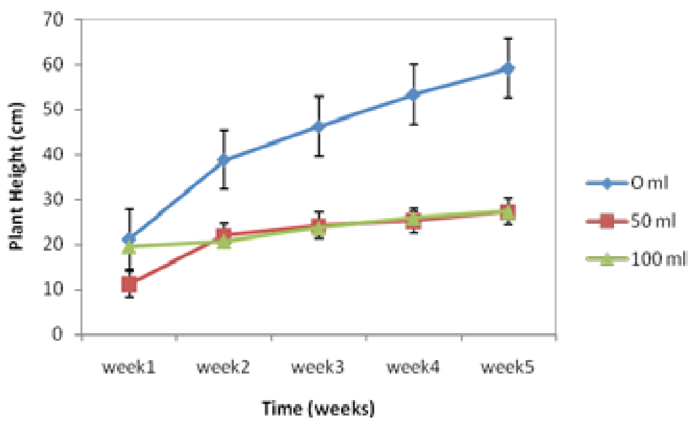

Fig 3: Plant height of *Zea mays* grown on spent engine oil contaminated soil

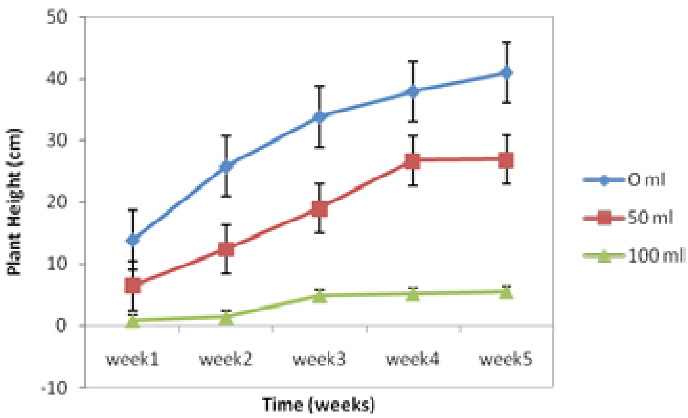

Fig 2: Plant height of *Sorghum bicolor* grown on diesel contaminated soil

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