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Effect of Nutrient Amendments of Diesel Oil Polluted Soil on Plant Growth Parameters

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Abstract: The study investigated the effect of nutrient amendments of diesel oil polluted soil on plant height, leaf area and leaf numbers of eggplant (*Solanum melongena*). Soil samples were polluted and amended separately with different weights of poultry waste, pig waste, cow dung and inorganic fertilizer. Soil samples were also polluted with diesel oil without amendment to achieve 2, 4, 6, 8 and 10% pollution. Samples were analyzed at two weeks interval for sixteen weeks. The plant growth parameters were affected adversely by the diesel oil pollution and the higher the level of pollution, the more the effect. The nutrient amendments were able to remedy the effect of the diesel oil pollution. The remediation effect was nutrient weight dependent and the best remediation effect was observed in poultry waste amended samples. This study has shown that diesel oil contaminated soil may have adverse effect on plants, but this can be remedied by addition of organic nutrient supplements especially poultry waste.

Key words: Diesel oil, eggplant, Nutrient amendments, remediation

INTRODUCTION

Pollution of the soil with petroleum derivatives is often observed in municipal soils around industrial plants and in areas where petroleum and natural gas are obtained (Adam *et al*., 2002; Clark, 2003). Processing and distribution of petroleum hydrocarbons (Ayotamuno *et al*., 2006) as well as the use of petroleum products leads to contamination of soil. Changes in soil properties due to contamination with petroleum-derived substances can lead to water and oxygen deficits as well as to shortage of available forms of nitrogen and phosphorus (Wyszkowska and Kucharski, 2000). Contamination of the soil environment can also limit its protective function, upset metabolic activity, unfavourably affect its chemical characteristics, reduce fertility and negatively influence plant production (Wyszkowski *et al*., 2004; Wyszkowski and Wyszkowska, 2005). This threatens human health and that of the organisms that are dependent on the soil (Aboribo, 2001). The increasing use of diesel oil in diesel engines of cars, industrial trucks and generators has led to an increased demand for diesel oil (Ogbo, 2009) and accidental spillage of diesel and pollution of agricultural lands. Diesel oil is one of the major products of crude oil and it constitutes a major source of pollution to the environment (Nwaogu *et al*., 2008). Diesel oil can enter into the environment through leakage from storage containers, refueling of vehicles, wrecks of oil tankers and warships carrying diesel oil and through improper disposal by mechanics when cleaning diesel tankers. Soil pollution through such many small and common sources of these products poses large environmental threat (Wyszkowski and Ziolkowska, 2008). Diesel spills on agricultural land generally reduce plant growth (Nwaogu *et al*., 2008). Diesel oil reduces soil fertility and soil microflora population (Torstenssen *et al*., 1998). Wyszkowski and Ziolkowska (2008) also reported that the addition of diesel oil to the soil led to a significant reduction of organic carbon content of the soil. Diesel oil is phytotoxic to plants at relatively low concentrations. Ogbo (2009) reported that diesel oil contamination of the soil caused a reduction in the length of the radicles of *Arachis hypogea*, *Vigna unguiculata*, *Sorghum bicolor* and *Zea mays.*

Treatment of soils with crude oil, Automotive Gasoline Oil (AGO) and spent engine oil significantly delayed the period of germination, reduced percentage germination, plant height, leaf production and biomass of *V. unguiculata* (Adedokun and Ataga, 2007). Addition of petrol to the soil in quantities above 2.5 cm^3/kg of soil

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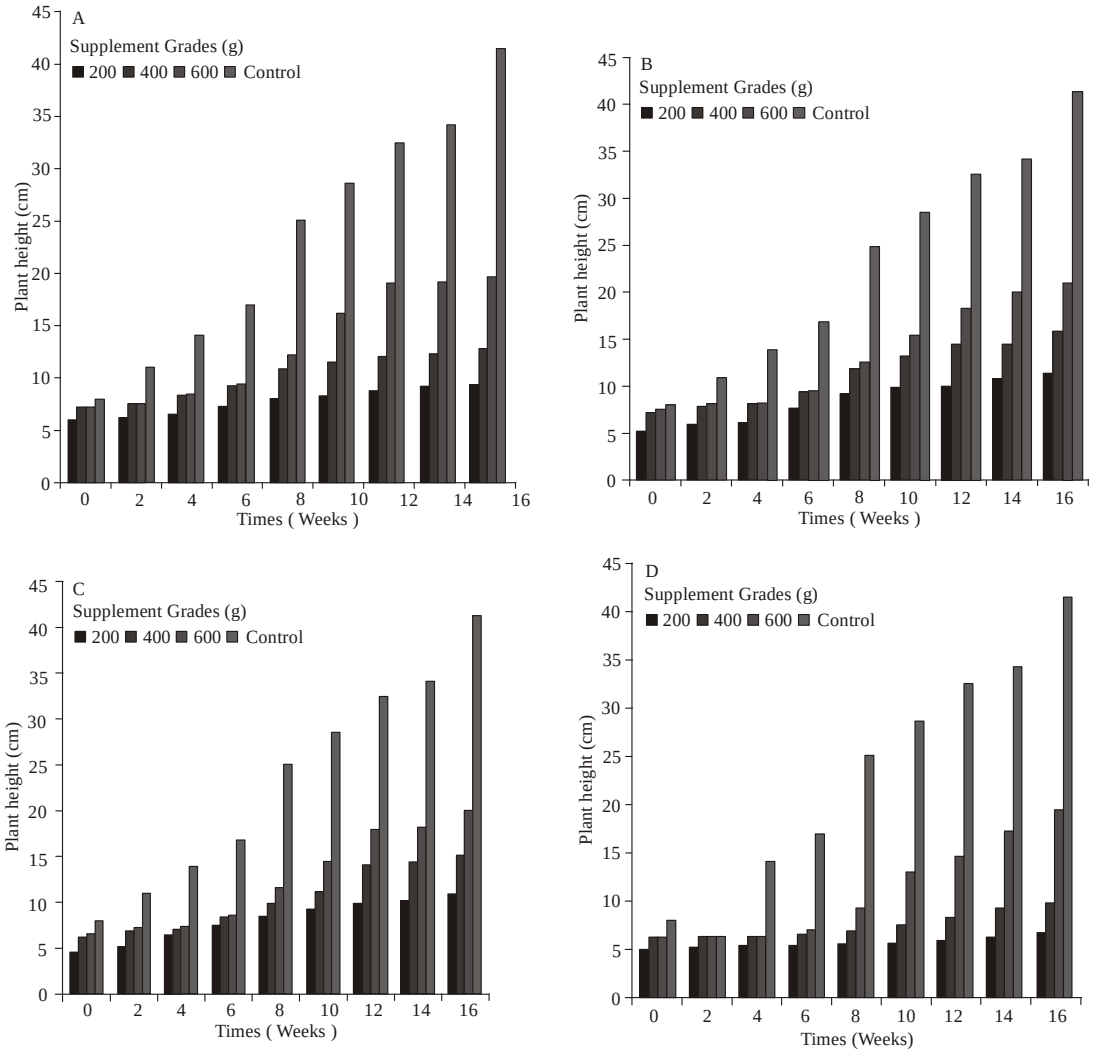

Fig. 1: Effect of heavy diesel oil pollution on plant height in (A) poultry waste (B) pig waste (C) cow dung (D) inorganic fertilizer amendedsamples

leads to decreased potassium levels in the soil (Wyszkowski and Ziolkowska, 2008). Although the effects of the individual petroleum products on plants have been evaluated by many studies (Siddiqui and Adams, 2002; Anon, 2003; Andrade *et al*., 2004; Adedokun and Ataga 2007; Shahid, 2007), there is the need to find out a remediation method to counter the effects of some of the petroleum products on plants. This study therefore evaluates the effects of diesel oil on the growth performance of eggplant and remediation effect of the different organic nutrient supplements.

MATERIALS AND METHODS

This study was carried out between April and December, 2010 in the department of Microbiology, Federal University of Technology, Owerri.

Sample collection and preparation: The soil samples used for this study were collected from a site in the School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology, Owerri (FUTO), Imo State, Nigeria. The samples were collected from 5-10 cm of the topsoil and transported to the preparation site in clean plastic buckets. The diesel oil was bought from Nigerian National Petroleum Corporation (NNPC) mega station, Owerri. The cow dung was collected from the Department of Animal Science Technology, FUTO. The pig and poultry wastes were obtained from Songhai Redemption farms, Nekede, Owerri, while the inorganic fertilizer (NPK 15:15:15) was bought from ADC Farms, Nekede, Owerri. Garden egg seedlings (*Solanum melongena*) were purchased from Relief market, Owerri, Imo State, Nigeria and identified by Dr Ferdinand Mbagwu, a plant taxonomist with the

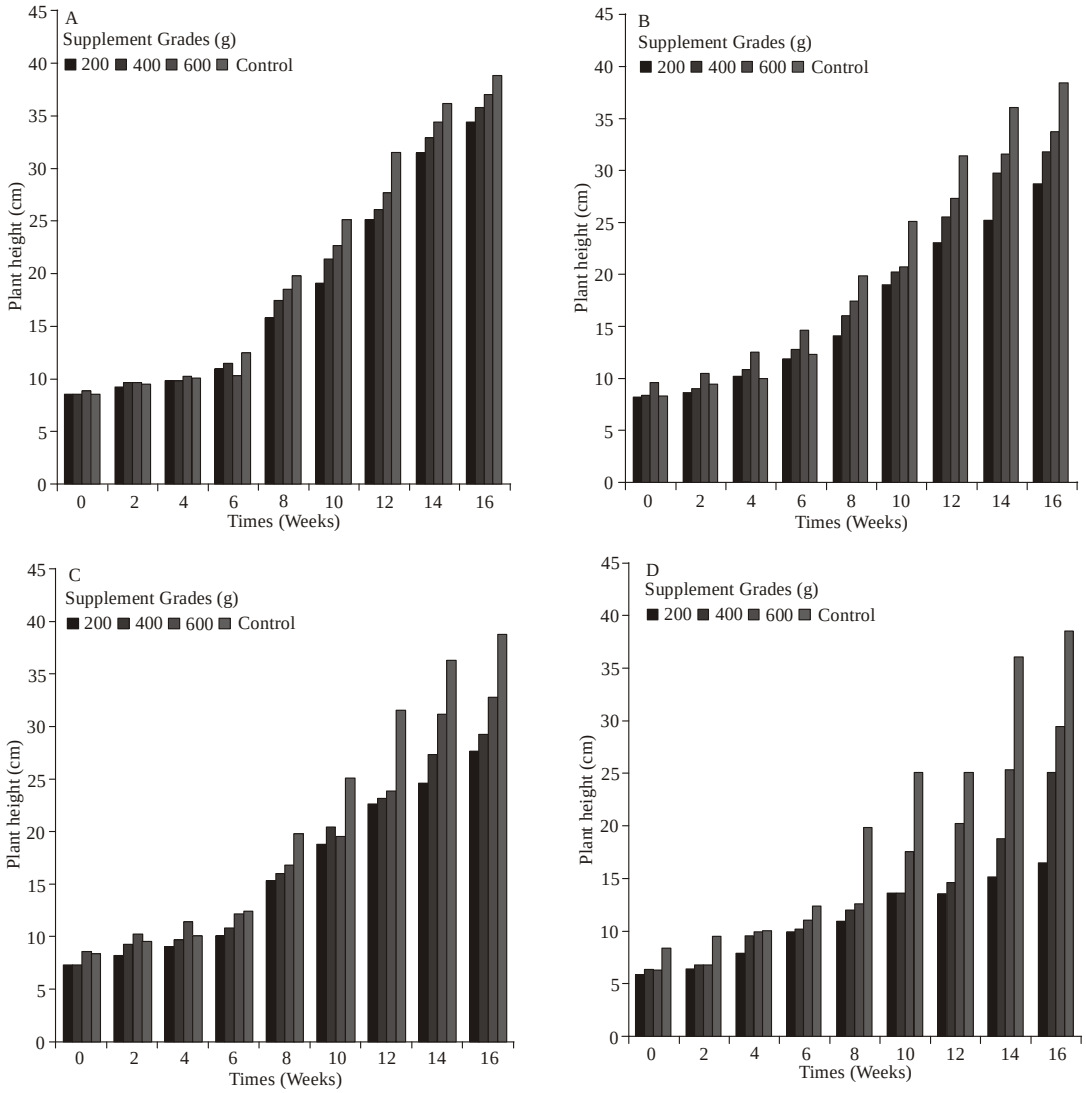

Fig. 2: Effect of moderate diesel oil pollution on plant height in (A) poultry waste, (B) pig waste, (C) cow dung, (D) inorganic fertilizer amended samples

Department of Plant Science and Biotechnology, Imo State University, Owerri, Imo State, Nigeria. To prepare the soil samples for diesel oil pollution, 84 kg of soil was properly mixed with 20 and 10 L of diesel oil respectively, for heavy and moderate pollution samples. These were dispensed into plastic buckets in 6 kg weights each and mixed with various quantities of organic (200, 400 and 600 g) and inorganic (100, 200 and 300 g) supplements. The samples were exposed to rain and sunlight throughout the period of the study.4 seedlings of garden egg plant. Samples were taken for analysis at 2 weeks interval for 16 weeks.

Plant growth parameters measurement: These include the plant height, leaf number and leaf area. The plant height was measured from the surface of the soil to the tip of the plant using a meter rule at an internal of 2 weeks for 16weeks. The leaf area was obtained in duplicates by placing the leaf on a graph paper of one square centimeter (1 cm^2). The squares enclosed by the margin were counted after the trace. The squares which were divided by the leaves area were counted if they are greater than or equal to 0.5 cm^2. Those that were less than 0.5cm^2 were ignored. The mean of the duplicate figures was taken as the leaf area. The leaf numbers were obtained by visual counting of the leaves. All the parameters were obtained at 2 weeks interval for 16 weeks.

RESULTS

The effects of heavy pollution of the diesel oil on the eggplant height in the amended samples are presented in

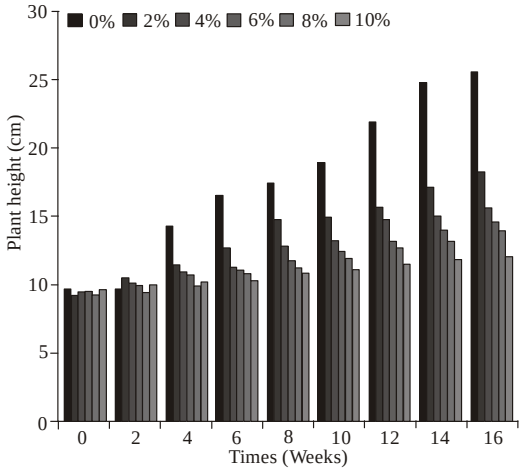

Fig. 3: Effect of the diesel pollution on plant height in the soilsamples polluted with graded concentrations of oil

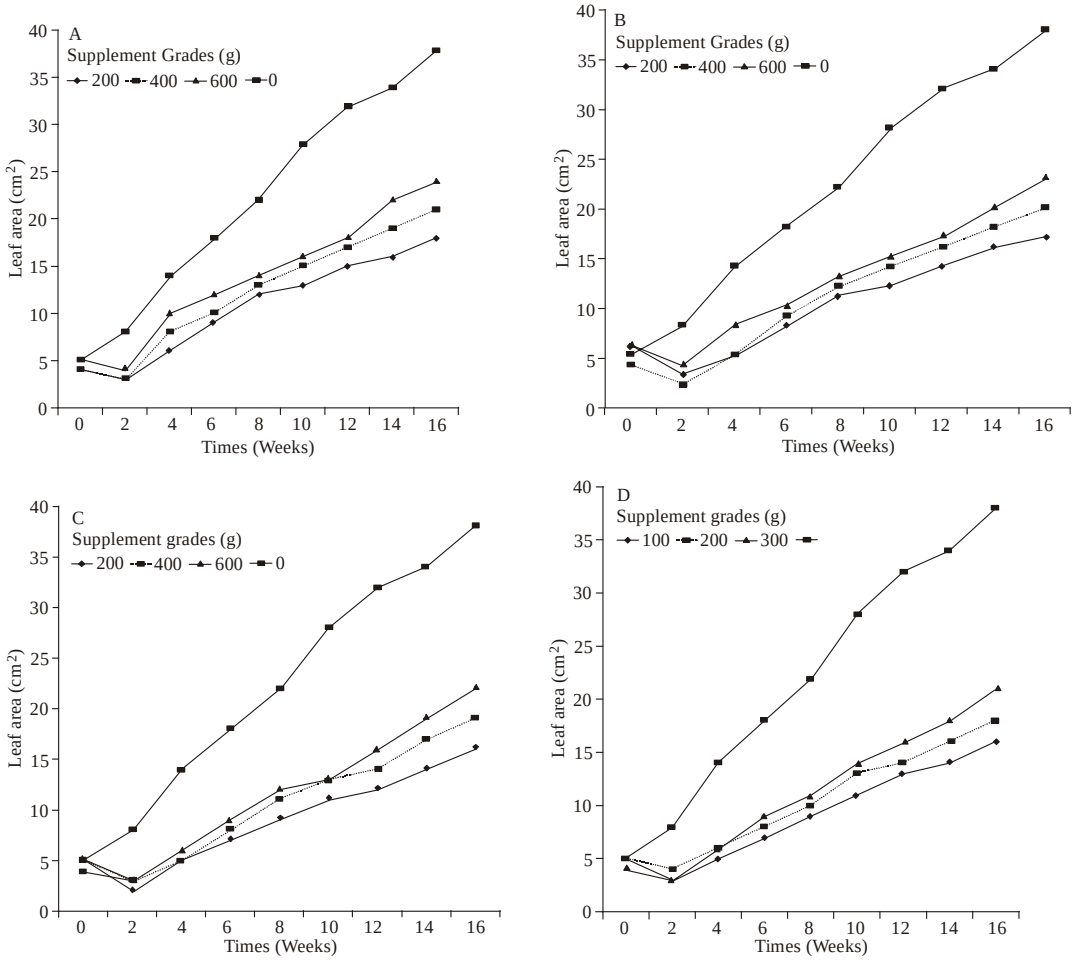

Fig. 4: Effect of heavy diesel oil pollution on leaf area in, (A) poultry waste; (B) pig waste; (C) cow dung; (D) inorganic fertilizer amended samples

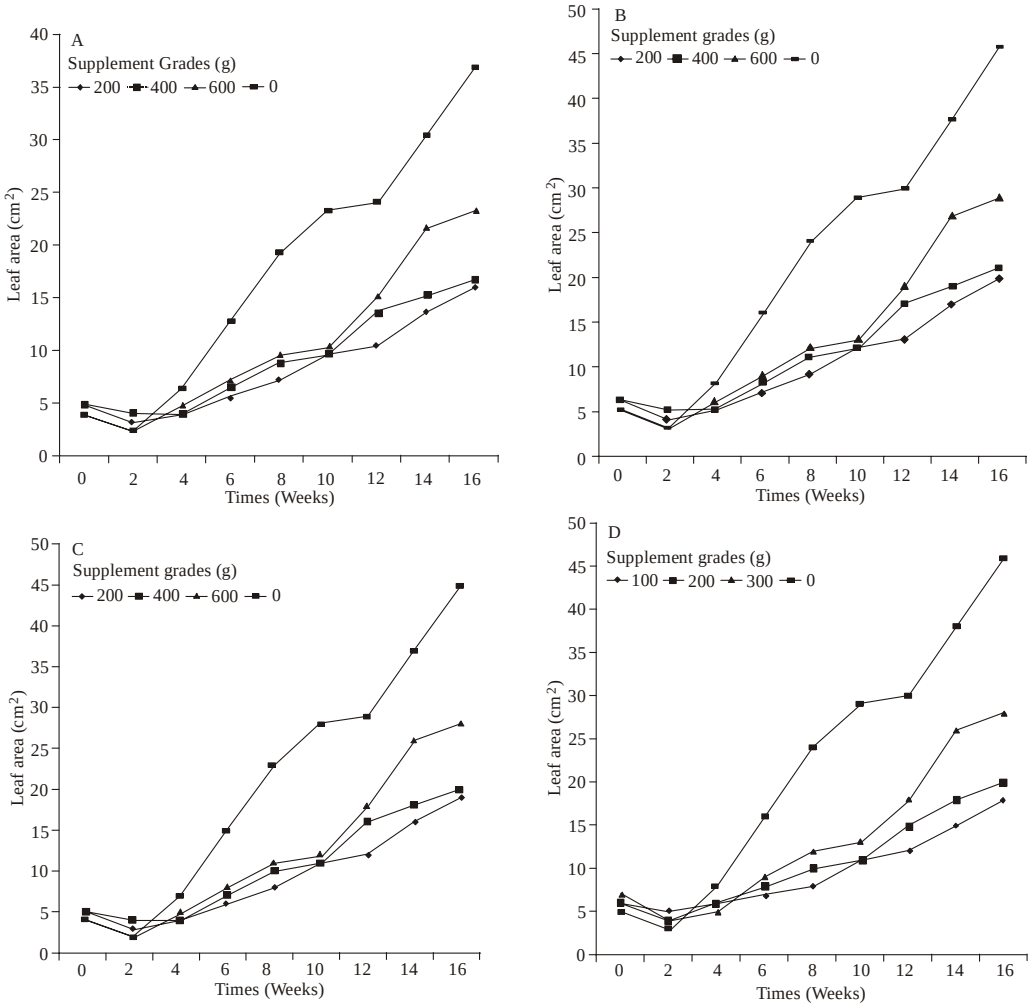

Fig. 5: Effect of moderate diesel oil pollution on leaf area in, (A) poultry waste, (B) pig waste, (C) cow dung, (D) inorganic fertilizer amended samples

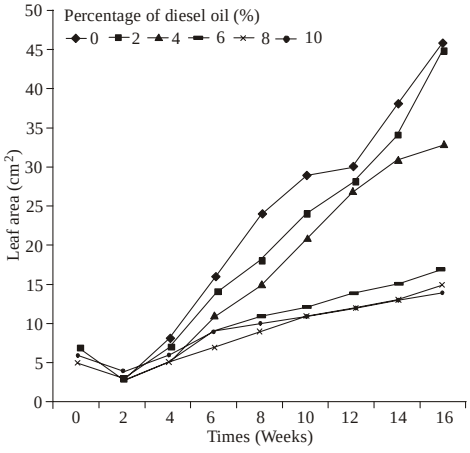

Fig. 6: Leaf area of egg plant on soil polluted with graded concentrations of diesel oil

Fig. 1(A-D). There was an increase in height of the eggplant with increase in the number of weeks in all the samples with a significant increase observed in the 16th week ($p<0.05$). There were variations in plant heights among the nutrient supplements with the highest observed in poultry waste-amended samples. The control had higher heights than the treatment samples in all the weeks.It was shown that the higher the quantity of the supplements, the higher the height in all the amendments. The effect by the moderately polluted soil samples also followed the same trend as the heavy polluted samples although the effect was significantly reduced (Fig. 2A-D).In the soil samples polluted with graded concentrations of diesel oil, the values of the plant height increased with increase in the number of weeks but decreased with increase in the percentage concentration of the diesel oil (Fig. 3). Plant heights in the control samples were significantly higher than those in the polluted samples

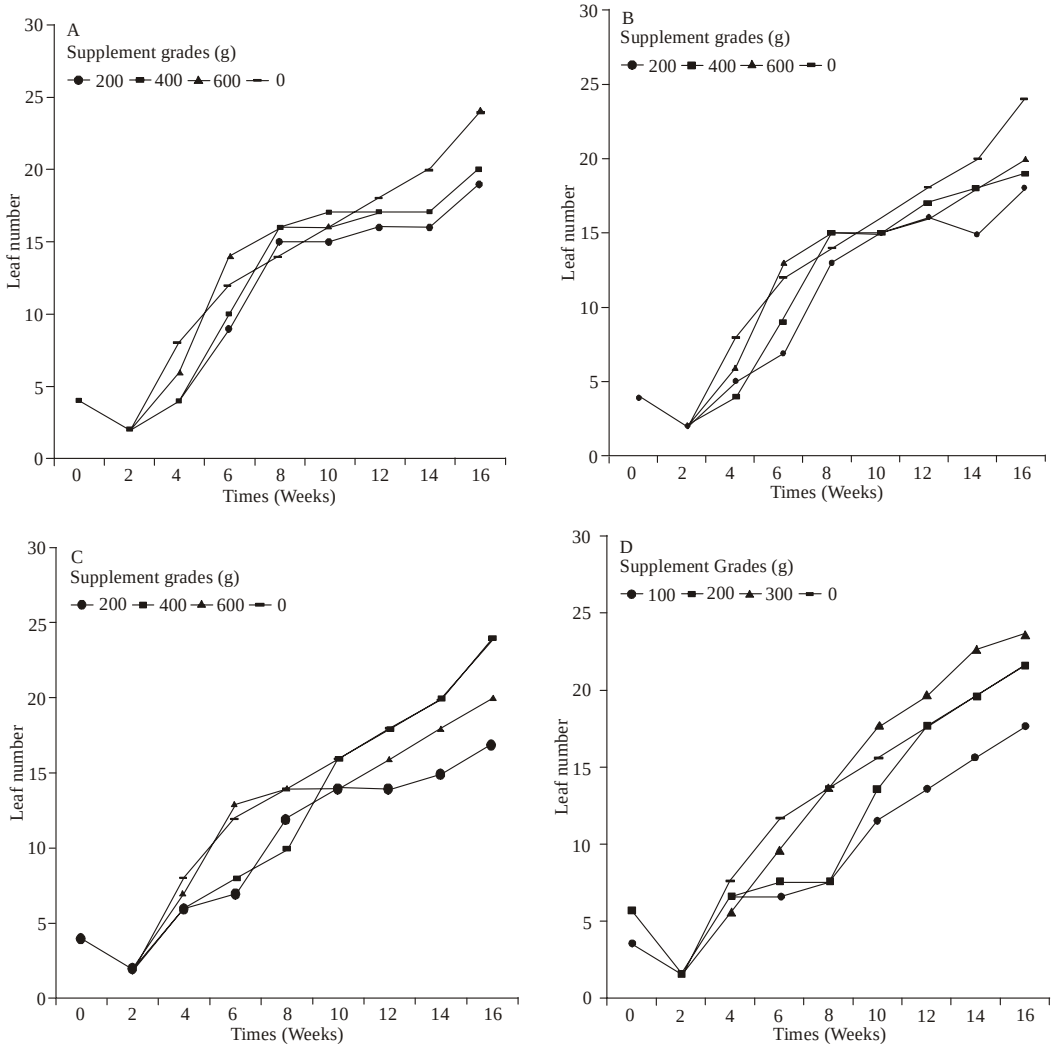

Fig. 7: Leaf numbers of eggplant on heavy polluted soil amended with (A) poultry waste, (B) pig waste, (C) cow dung, (D) inorganic fertilizer

($p<0.05$). The leaf areas of the eggplants in the heavy and moderate polluted samples amended with supplements differ from each other according to the level of pollution and type of nutrient supplement. There was a direct proportionate increase in leaf area with increase in the quantity of supplements but inverse proportionate increase with increase in the level of pollution (Fig. 4A-D and 5A-D). The leaf area of the eggplant on soil polluted with different percentage concentrations of diesel oil is presented in Fig. 6. It was observed that the level of pollution had adverse effect on the leaf area with the highest effect observed in the 10% diesel oil pollution in the 16th week (14 cm^2).The effects of diesel oil pollution on leaf numbers were as well observed as in the other parameters and presented in (Fig. 7A-D and 8A-D). There was an increase in the number of leaves as the quantity of the supplement increased and also as the number of weeks increased though there was a reduction in the number of leaves on the 2nd week which later increased from the 4th week. The level of pollution also had adverse effect on the leaf numbers which reduced proportionately with increase in the level of pollution. Figure 9 shows the leaf numbers of the eggplant in the samples mixed with different percentage concentration of diesel oil. Generally, there was an increase in the number of leaves with decrease in the percentage concentration of the diesel oil with the highest number of leaves observed in the 16th week in the control sample (0%) (27 leaves).

DISCUSSION

Diesel oil like the other petroleum products adversely affects the growth and performance of plants as indicated in the results. The effect of the diesel oil on the plant height observed here were similar to those reported on the effect of spent oil on *Amaranthus hybridus* (Odjegba and

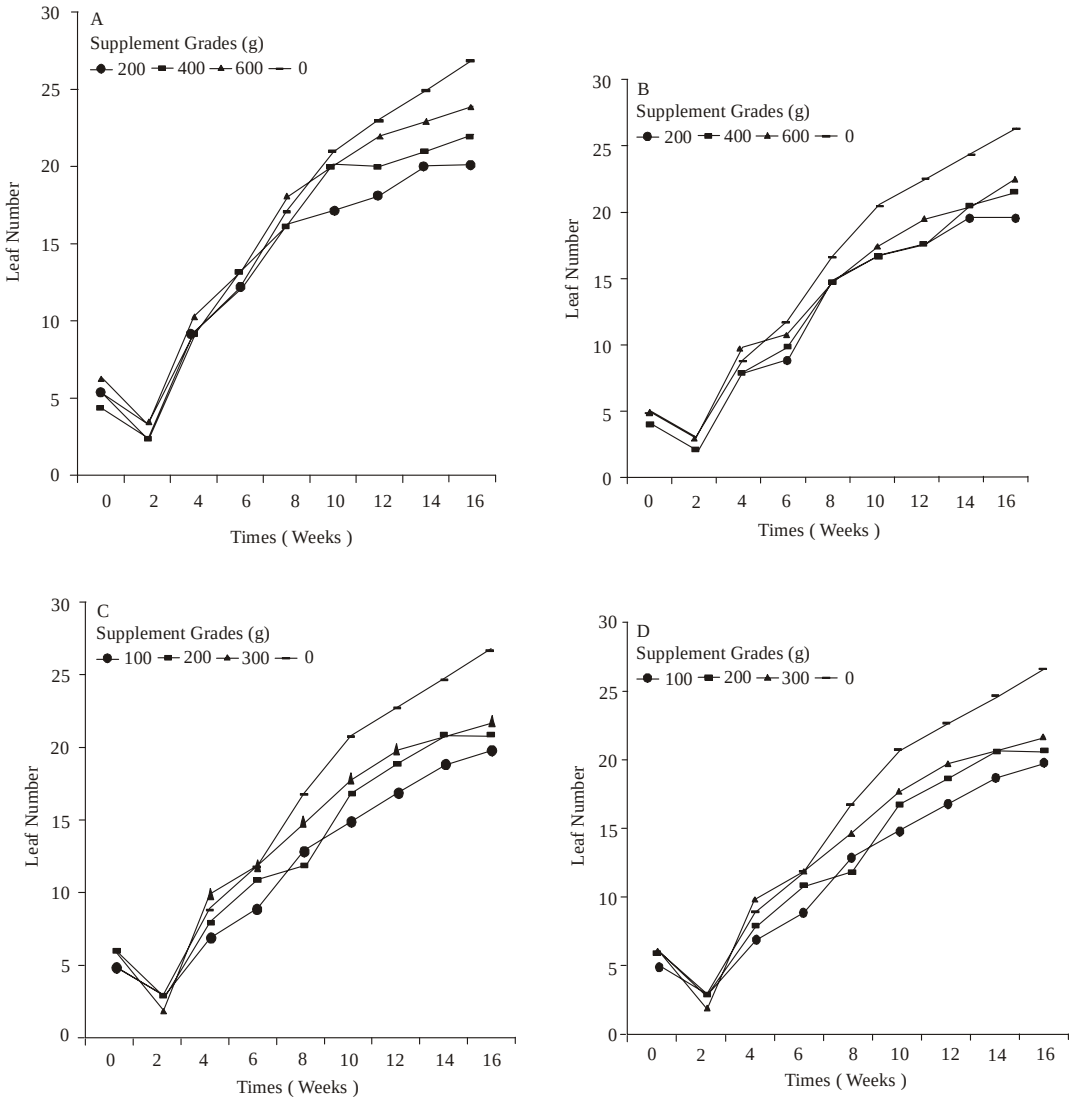

Fig. 8: Leaf numbers of eggplant on moderate polluted soil amended with , (A) poultry waste, (B) pig waste, (C) cow dung, (D) inorganic fertilizer

Sadiq, 2002). Njoku *et al*. (2008) also found similar findings on the effect of crude oil the growth of accessions of *Glycine max* and *Lycopersicon esculentum*. Adedokun and Ataga (2007) also showed that treatment of soils 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* delaying germination and growth rate. Sun *et al*. (2004) made similar observation when they studied the effect of diesel fuel on the growth of *Nerlum oleander*, beach naupaka, false sandalwood, common ironwood, kou, milo and kiawe. The effect on leaf area diesel pollution of soil indicates that the diesel oil interrupts with the growth of the plant. According to Kathirvelan and Kalaiselvan (2007) the leaf surface area determines in large part the amount of carbon gained through photosynthesis and the amount of water lost through transpiration and ultimately the crop yield. Therefore the reduction of the leaf area as was observed in this study implies that there would be low a photosynthetic efficiency of the plant as much of the solar energy emitted by sun would not be absorbed by plant for photosynthesis. This can lead to low yield of the plant with subsequent low availability of food and poor economy due to low sales of such plant's products. According to Walker *et al*. (2001), availability of nitrogen in the soil directly affects the relative growth rate of plants. Since petroleum-products are known to reduce nitrogen availability (Agbogidi *et al*., 2007), that could be the cause of adverse effect on the plant growth parameters

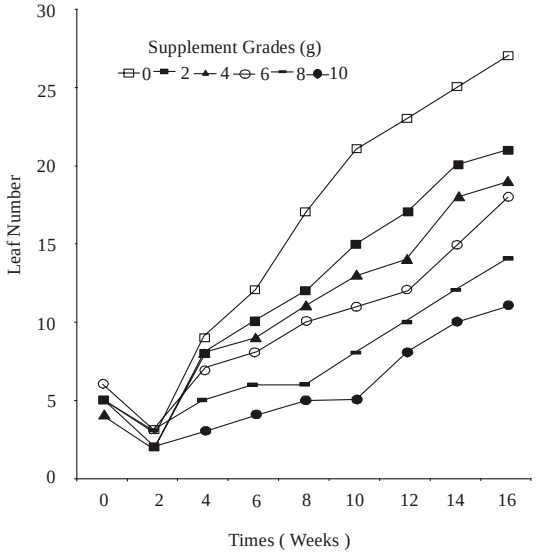

Fig. 9: Leaf Numbers of the eggplants on samoles with graded concentration of diesel oil

with increase in the percentage concentration of the diesel oil pollution. The effect was reduced by the addition of nutrient supplements because it has been shown that plants grow slower under low nutrient levels (Grotkopp and Rejmanek, 2007). According to Wyszkowski and Zoilkowska (2008), proper growth of cultivated plants is dependent on the content of nutrients in the soil. The inhibition of the growth of the eggplant observed in this study therefore possibly occurred due to the effect diesel oil had on soil. The adverse effects could be due to disruption of the absorption and uptake of nutrients by petroleum products (Njoku *et al*., 2008). The degrading effect of petroleum - derived compounds on soil leads to severe nitrogen and phosphorus depletion, depletion of water balance and biological equilibrium (Baran *et al*., 2002). Dimitrow and Markow (2000) showed that the presence of oil in the soil significantly decreased the available forms of phosphorus and potassium to plants. These nutrients (nitrogen, phosphorus, potassium and oxygen) are essential to plat growth and development hence reduction in their bioavailability will lead reduced plant growth. From the study, it can be concluded that diesel oil contaminated soil may result in low soil fertility. But this can be remedied by the addition of organic nutrient supplements especially poultry waste and the quantity supplement added has significant effect on the remediation process. Moreover, it can be deduced from this research work that plants can perform relatively better in diesel polluted agricultural soil if such soil is amended with reasonable quantity of animal waste especially poultry waste while the autochthonous microbiota naturally attenuates the petroleum hydrocarbon.

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