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Effects of Crude Oil Contamination on Seeds Germination and Growth of *Arachis Hypogea* and *Citrullus Vulgaris*

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ABSTRACT

The effects of crude oil contamination on the germination, and growth of groundnut (*Arachis hypogea L.*) and egusi melon (*Citrullus vulgaris L.*) were investigated in a green house under control environmental condition. Planting was done in a wide open black polythene bag filled with 10kg of 2mm sieved soil. Eight polythene bags, each per crude oil concentration were used (four polythene bags for groundnut and four for egusi melon). Treatment of the soil was carried out by adding varying concentration of crude oil raging from 0, 0.5, 2 and 5% into soil sample content in the polythene bag. Each concentration of crude oil was added to each soil sample in each bag (four bags for groundnut and four bags for egusi melon) and was thoroughly mixed using gloved hands. Seeds of groundnut (*Arachis hypogeal L.*) were planted into each of the four polythene bags with soil sample treated with varying concentration of crude oil and Seeds of Egusi melon (*Citrullus vulgaris L.*) were planted to each of the other four polythene bags of soil sample treated with vary concentration of crude oil. The result indicated that crude oil pollution of 2 and 5% significantly reduced the germination and growth of the *Citrullus vulgaris* (melon) while in *Arachis hypogeal* (groundnuts), germination increased with increase in crude oil contamination of up to 5%. At 5% oil level, all the seeds of groundnut germinated but with time there was a reduction in the growth parameters possibly due to the coagulatory effect of increasing crude oil on the soil binding the soil particles into water impregnable soil block which impaired water drainage and oxygen diffusion. Also the tolerance exhibited by groundnuts could possibly be linked to its ability to fix nitrogen.

KEYWORDS: Crude Oil, Soil contamination, Seed Germination, Growth Parameters, Groundnut (*Arachis hypogeal L.*) and Melon (*Citrullus vulgaris L.*)

1.INTRODUCTION

In the Niger Delta area, the environment is frequently polluted by oil spills, resulting from the activities of the oil exploration and production, accidental discharge, and sabotage. There is always a constant threat to agricultural activities, afforestation and coastal protection as a result of toxic effects of crude oil pollution on land, swamp and water. This threat ranges from delay in seeds germination, plant performance, changes in soil physical and chemical properties to disruption of an entire ecosystem.

Research has shown that crude oil pollution has deleterious effects on agricultural lands and plants. It also causes delay and reduced germination, reduced growth parameters. These hinder water and oxygen transfer between seed and the surrounding environment (Tarek Youssef, 2001; Ekundayo et al., 2001; Spiares et al., 2001; Adam and Duncan, 2002; Adewole et al., 2002; Odjegba and Sadiq, 2002; Asuquo et al., 2002; Uzoho et al., 2004; Agbogidi and Nweke, 2005; Ekundayo and Obuekwe, 2005; Ogbo, 2009 and Ekpo et al., 2012;).

Land pollution by crude oil is of significance to plant, soil and the living organisms in the entire ecosystem. This is because crude oil pollution whether on land, swamp and water has the potential of destabilizing an entire ecosystem. Delay in seeds germination and disruption of plant growth can hinder/disrupt agricultural yields (Bob-Manuel and Johnson, 2001; Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013).

In Nigeria, groundnut and melon are staple food crops consumed by almost every household in both southern and northern parts of the country. Groundnut is known botanically as Arachis hypogea belonging to the legume family with seeds rich in oil (45-49 %) and about 26 % protein used for food by human beings and livestock. Depending on the variety, the plant has short stem reaching

a height of 15 cm and the leaves are compound and pinnate with four leaflets. The flowers are yellow and the pods which are borne at the root may contain two or five seeds. The two varieties of groundnut are the upright and the spreading varieties.

Propagation is by seed. The climatic and soil requirements are best in area of between 700-1250 mm rainfall per annum and well distributed and drained on light sandy-loamy soil. Groundnut matures in about 120-140 days and harvesting commences when most of the leaves have turned yellowish and begun to drop. Harvesting is done by pulling out or lifting the individual plant and then picking the pods at the base along the stolon.

Melon is known botanically as Clocynthis citrullus. L also known as Citrullus vulgaris. It belongs to the Family curcumbitaceae and to the tribe Benicaseae. They are vine like herbs, tender-clumsy or prostrate annuals with soft stems which are slender and hairy, single breed, deeply cut leaves and with large fleshy fruit. It thrives in hot regions with rich light soil and can tolerate periods of low rainfall. The crop is cultivated for its seeds in Nigeria during the beginning of raining season April through June and harvested at the onset of dry season in the month of (October through December. In south-East and South south part of Nigeria, melon is referred to as Egusi. The seeds are prepared into condiment used especially in preparing soup (Ogbonna, 2013). Harvesting is done by collecting and cutting the fleshly gourds, and allowing them to ferment. The seeds are then extracted from the gourd after fermentation, dried and stored. The seeds are rich in oil about 53.1 % protein, about 33.8 % vitamins and very low in fat. Melon is grown both in Northern and Southern parts of Nigeria.

A review of previous studies showed that not much work was done on the effects of crude oil contamination of staple food crops such as groundnuts and melon. This study is therefore aimed at investigating the effects of crude oil contamination on seeds germination and growth of Groundnut (Arachis hypogeal L.) and Melon (Citrullus vulgaris L.) to determine their tolerance to crude contaminated soil.

1.2 The Study Area

The study area was River State University, Port Harcourt. The Univrsity is located along the west axis of Port Harcourt between Longitudes 60 50' - 70 00'E and Latitudes 40 45'-40 48'N (Figs. 1 and 2). The area is located in tropical humid zone with distinct wet and dry seasons. The wet season is usually long beginning from March and continues through October while the dry season is from November to February being short and are not even free from occasional rainfall (Gobo, 1990). The maximum rainfall occurs between June and October with mean annual rainfall of 2630 mm while the mean monthly temperature ranges between 28 oC and 33 oC with monthly minimum of 20 - 23 oC. The highest temperature Figures are recorded during the months of December to March. The Area has acidic sandy loam top soil classified as – Typic Paleudult.

2. MATERIALS AND METHODS

Study site: The study site was in a greenhouse house, located in the Department of Crops/Soil Science of the Rivres State University, Port Harcourt.

2.1 Experimental Treatments and Design

The soil for the experiment was collected from a long uncultivated land located at Okocha, Rumuolumeni, Port Harcourt. The Soil was air dried and sieved with 2 mm sieving net. It was then measured and weighed (10 kg) eac, into a wide open black polyethylene bag. Four bags of 2 mm sieved soil of 10 kg each, was for Egusi melon seeds and another four bags of 2 mm sieved soil of 10 kg each, for groundnut seeds. The groundnut seeds of palm nut (Upright) variety and egusi seeds of land race variety were obtained from Imo State Agricultural Development Programme (ADP). For each set, light crude oil obtained from Port Harcourt Refinery was applied at various concentrations of 0, 50, 200 and 500 mls corresponding to 0, 0.5, 2.0, and 5.0% based on weight of oil/weight soil. This was done to each of the 10 kg soil for the two sets of groundnut soils (GNS) and egusi melon soils (EMS) respectively (GNS1, GNS2, GNS3, GNS4 and EMS1, EMS2, EMS3, EMS4).

The experimental design was completely randomized, replicated three times. The crude oil was applied evenly and well mixed with gloved hands and left for five days. After five days of treatment, egusi melon seeds and groundnut seeds each, were sown in each of the bags and both coded as GN1, GN2, GN3, and GN4 representing groundnut seeds/seedlings and EM1, EM2, EM3 and EM4 representing Egusi Melon seeds/seedlings. Watering was made every two days interval. As they germinated/grew, the following parameters were measured/analyzed and recorded after every two weeks.

These were measured and recorded on seeds and germinating seeds and seedlings: Days for Seeds germination, number of Seeds germinated/emergence, Plant development, Plant height, Leaf' length and area. Seeds germination and emergence were observed, counted and recorded daily and every two weeks thereafter. The height of plant, the length and the area of leaves were measured and counted and recorded 2 weeks, 4 weeks, 6 weeks and 8 weeks after crops germination/emergence. Percentage Germination/emergence (%) was calculated as:

$$\text{Percentage Germination/emergence (\%)} = \frac{\text{Number of seeds germinated x100}}{\text{Total number of seed sown}}$$

Plant height, leaf length and leaf area were measured using meter rule. The analysis of variance (ANOVA) was used to test the effect of different crude oil concentrations on Seed

germination and growth. Where the effect created a significant impact at p <0.05 probability level, the standard error of means (SEM+) was used to compare the means. The relationship existing between the various growth characteristcs of the melon and groundnut seeds/seedlings were established using correlation analysis.

3. RESULTS

The results of the crude oil contamination on seeds germination and plant growth of both egusi melon and groundnut are presented in Figures 1- 7.

The results of seeds germination and emergence, showed that in egusi melon (Citrillus vulgaris), seeds germination/ emergence decreased with increase in concentration of crude oil contamination (Figures 1- 4). The average seeds germination for egusi melon at the end of week 8 was 80.3% in the control, 87.8% in soil treated with 0.5 % crude oil, 42.5 % in soil with 2.0 % crude oil contamination and 22.4 % in soil with 5.0 % crude oil contamination. Germination was observed to have commenced in all the treatments 5 days after planting and began to increase until the sixth week after planting (WAP). The rate of germination was fast at the beginning but decreased with increasing crude oil treatment.. Conversely, in groundnut seeds (Arachis hypogeal) the reverse was the case. Seeds germination and emergence increased with increase in concentration of crude oil treatment. The average seeds germination for groundnut at the end of week 8 was 46.9 % in the control, 27.8 % in soil with 0.5 % crude oil contamination, 47.2 % in soil treated with 2.0 % crude oil and 87.0 % in soil with 5.0 % crude oil contamination. Germination was also observed to have commenced in all the treatment 5 days after planting (DAP) except in soil with 0.5 % crude oil treatment where there was no germination until 7 days after planting (DAP) and germination increased until the 8 WAP.

The rate of germination was slow at the beginning but later increased with increasing crude oil treatment. The groundnuts with highest crude oil treatment (5 %) had all its seed germinated. The analysis of variance on seed germination showed that for egusi melon, at p<0.05, 2 % oil treatment showed a significant effect on the seeds germination and emergence 2WAP, at p<0.01, 5 % oil treatment showed a similar effect 2WAP: Groundnuts, at p<0.05, 0.5 and 5 % oil treatment showed significant effect on germination and emergence 6 WAP and 8 WAP. In addition, analysis of variance also showed that there was significant differences (P <0.05) on total germination of egusi melon and groundnuts.

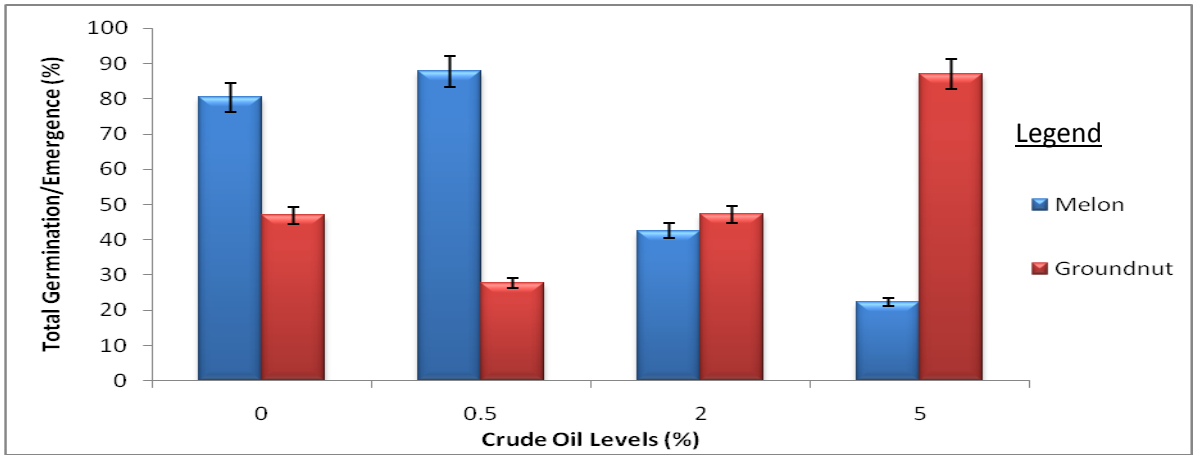

Figure : 1.Effects of crude oil pollution on total percentage germination/emergence of melon and groundnut 2, 4, 6 and 8 WAP.

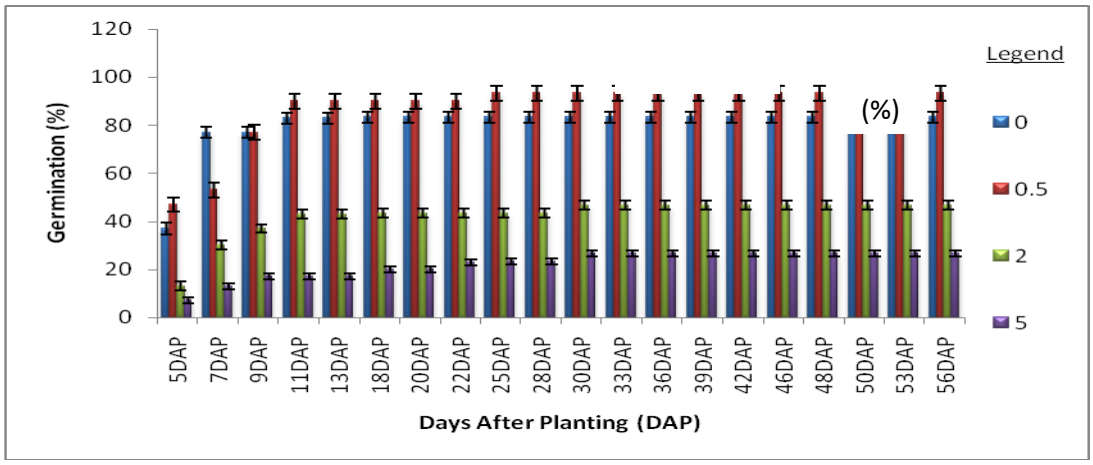

Figure 2: Effects of crude oil pollution on germination of melon days after planting.

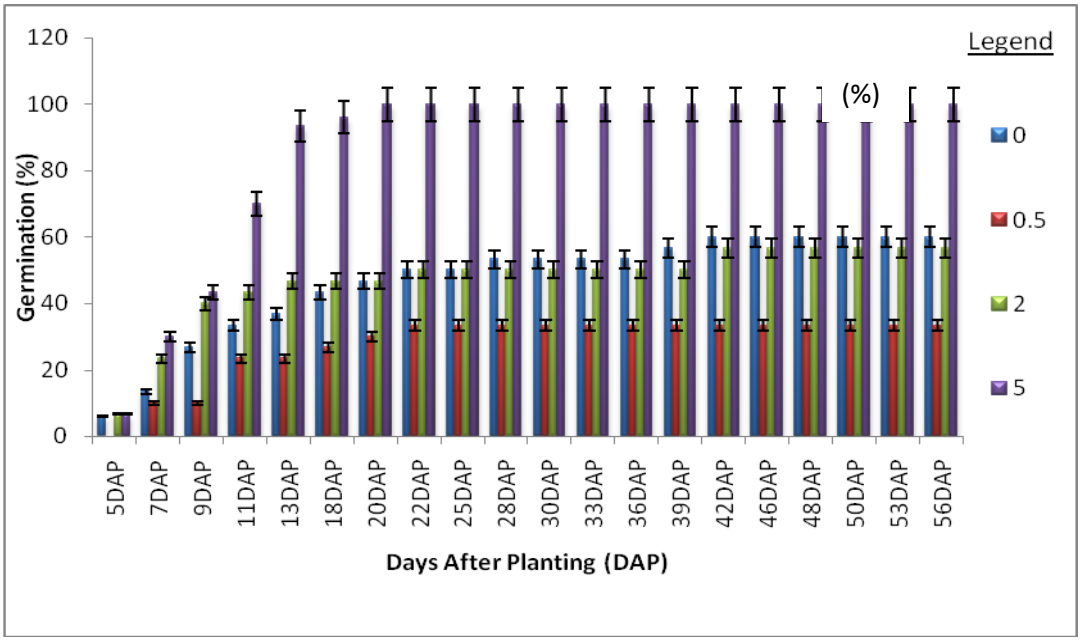

Figure..3: Effects of crude oil pollution on germination of groundnut days after planting.

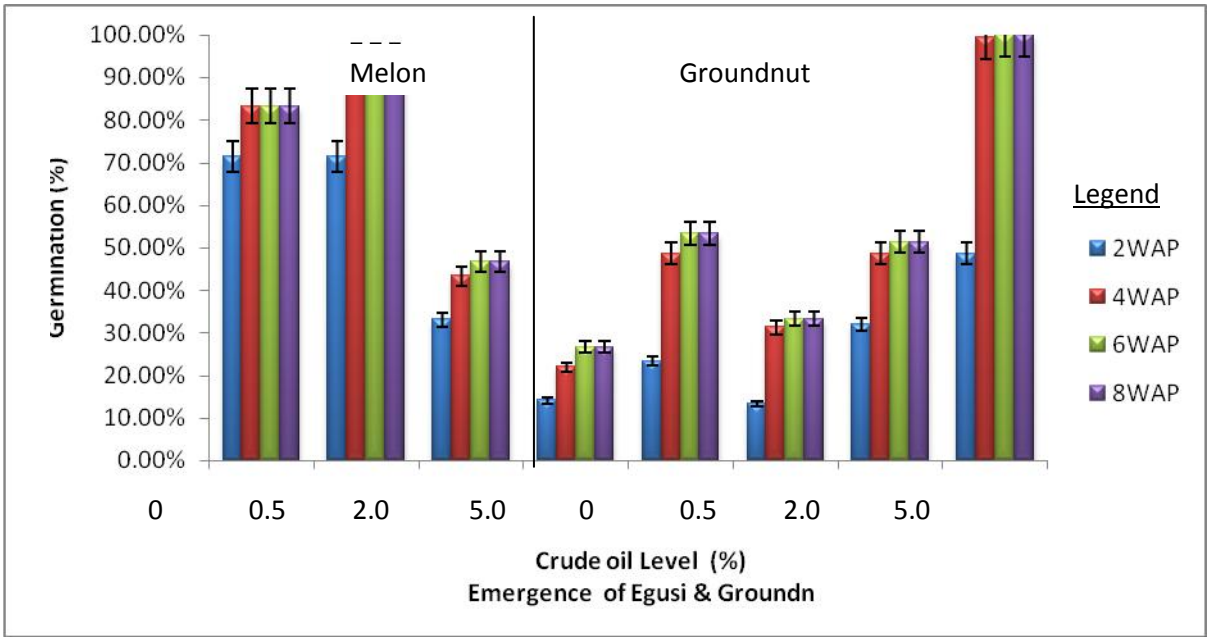

Figure. 4: Effects of crude oil pollution on cumulative germination of melon and groundnut weeks after planting.
WAP = Week after planting.

3.1 Plant height.

The result showed that in a egusi melon, the average plant height decreased with increase in concentration of crude oil treatment (Fig.5). This was also confirmed by visual observation as seen in all the plates while in groundnuts, the result showed that the effect on height is felt much on groundnut seedlings with higher percentage of crude oil contamination (5%) and not much on that of 0.5% and 2% treatment when compare to the control (Fig 5). This was also confirmed by visual observation as seen in all the plates.

The results of crude oil contamination on plant's height showed that for egusi melon seedlings, at $p<0.05$, 2% oil treatment shows direct significant effect on height/ length of stem 8 WAP and at $p<0.01$, 2 and 5% oil treatment showed significant direct (positive) effect 4, 6, 8 and 2 WAP respectively while in groundnuts Seedlings, at $p<0.05$, 0.5% oil treatment showed an inverse relationship 4 WAP and at $p<0.01$, 2 and 5% oil treatment showed a direct significant effect 6WAP, 4WAP and 2WAP respectively. The analysis of variance also showed that there were significant effect on the various growth parameters including the height/length of stems of egusi melon and groundnuts seedling.

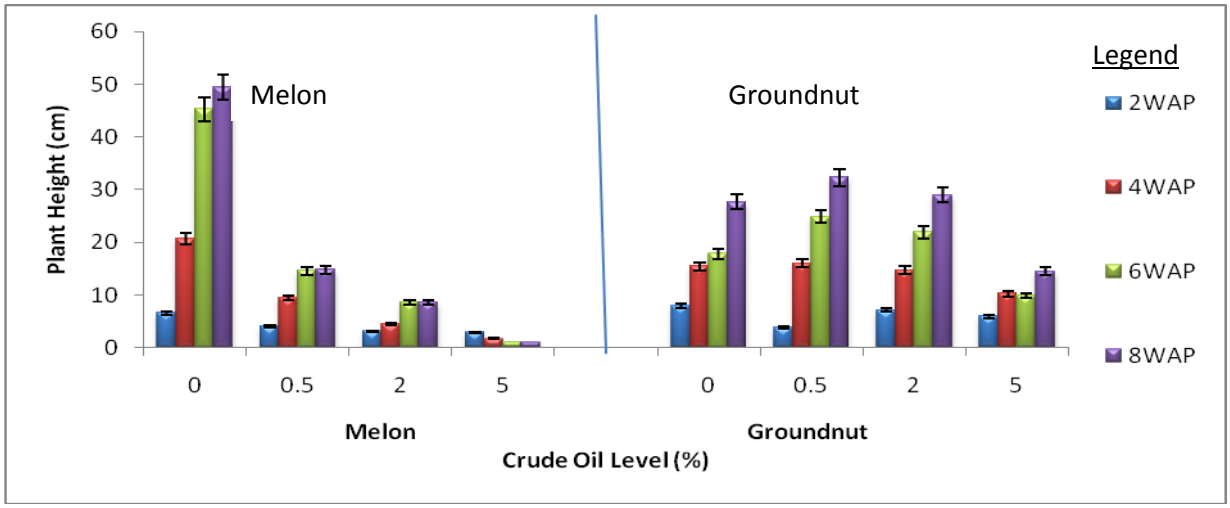

Figure 5: Effects of crude oil pollution on plant height of melon and groundnut.

WAP = Week after planting.

3.2 Leaf Length and Area

The result of egusi melon and that for groundnut showed that the average length and area of leaves decreased with increase in concentration of crude oil treatment in both egusi melon and groundnut pots but was more pronounced for Egusi melon (Figs 6 and 7). As the oil concentration increased, groundnut leaves with 5% crude treatment, reduced in size, and turned yellowish at the base and withered. These signs were mild in groundnut leaves in soil with 0.5 and 2.0% treatment.

The reduction in leaf sizes began with the seedlings in soil with 0.5% oil level followed by that of 2.0% though not significant and then very pronounced in that of 5% oil treatment while that of egusi melon was worse. Some of the leaves got shrank with white dots and turned either yellowish or green-yellowish and some eventually withered as the concentration increased from 0.5 to 5% treatment.

The results showed that effect of crude oil contamination on the leaf length and area of egusi seedlings, at $p<0.05$, 2 and 5% oil treatment was significant on the length of leaves 6 and 4 WAP, while on the leaf area,, at $p<0.05$, 2% oil treatment showed a significant effect 8 WAP. In groundnuts seedlings, at $p<0.05$, 0.5% oil treatment showed an inverse relationship on the lengths of the leaves 4 WAP and at $p< 0.01$, 2% oil treatment showed a significant effect on the length of leaves 4 WAP while at $p<0.01$, 0.5 and 5% oil treatment showed a significant effect on the areas of leaves.

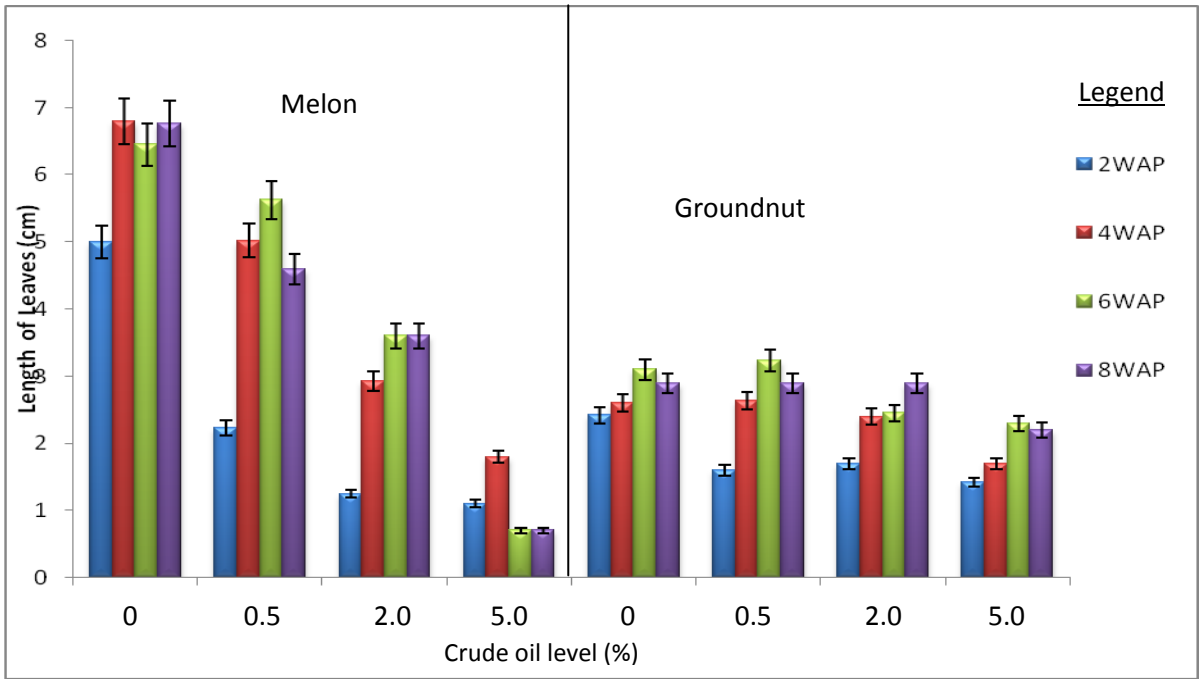

Figure 6: Effects of crude oil pollution on length of leaves of melon and groundnut.

WAP = week after planting.

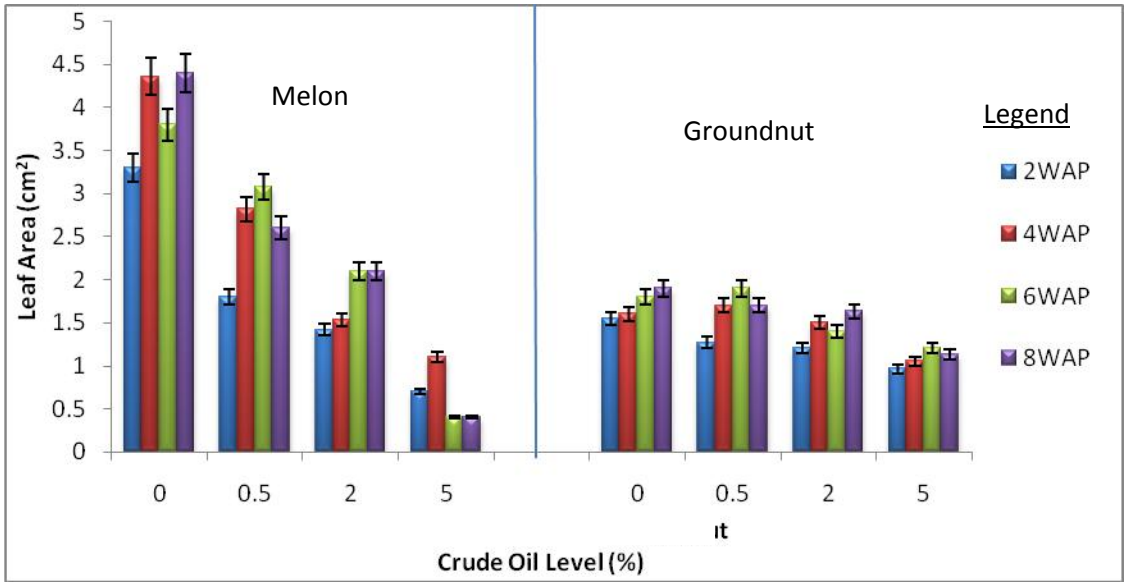

Figure 7: Effects of crude oil pollution on leaf area of melon and groundnut.
WAP = Week After Planting.

4. DISCUSSION

The effect of various levels of oil treatments on soil physico-chemical properties, seeds germination and plant growth of melon and groundmut seeds and seedlings, revealed that oil treatment at 2 and 5 % adversely afected all the agronomic characters of melon than of groundnut (Figs. 1-7). Increase in the amount of crude oil treatment made the soil to stick together. Soil with 2 and 5 % oil treatments were observed to be stuck together than that with 0.5 % and the untreated soil. This coagulatory effect of soil particles impaired water drainage and air diffusion and these findings are in accordance with the previous reports of (Gill et al., 1992; Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013).

The results on seeds germination/emergence and plant growth revealed that treatment levels of 0 - 0.5 % had a remarkable higher effect on germination and emergence in melon than 2 and 5 % oil levels. Emergence in case of the later was less than 50 %. This is in agreement with earlier report by Isirimah (1989), that light oil concentration of about 1 % is beneficial to plant. The result revealed that 0.5% crude oil contamination enhanced seed germination in melon when compared to the control, and above 0.5% adversely affected seeds germination and emergence of melon. These effect ranges from delay in germination to retarded emergence as shown in Figs. 1-4. This is also in agreement with Gill et al. (1992), Cambel and Valvrik (1997), Rhykerd et al. (1998), Ekundayo et al. (2001), Spiares et al. (2001), Adewole et al. (2002), Agbogidi and Nweke (2005), Townsend et al. (2003); Labud et al. (2007) and Sutton et al. (2013). These scientists reported that growth of plant on oil polluted soil was generally retarded resulting in chlorosis of leaves, coupled with dehydration of the plant indicating water deficiency. The low level of crops germination and emergence in high level of oil treatment in melon is attributed to poor wetability and aeration (Gill et al., 1992 and Aislabe et al., 2004).

On the other hand, the groundnut seeds sowed in the soil with various treatment levels showed that germination and emergence increased with increase in oil levels and that low oil levels of 0.5 % was observed to suppresed germination in groundnut while oil level above 0.5 % and 5 % enhanced germination in groundnuts. Treatment levels of 2 and 5 % had a significantly higher germination and emergence than in the untreated soil (control) and 0.5 %. Emergence in case of 5 % oil level was over 80 %. The result of this study showed that there are crops like groundnut that can tolerate higher levels of oil treatment. The tolerance ability may be from the fact that it has ability to withstand drought and oxygen deficiency and was able to maintain a steady food component through out the duration as shown in Figs. 1 - 4. Also, since plants need carbon to grow, increased in organic carbon with increase in crude oil could also be another reason for this tolerance. In addition, since groundnut is a leguminous plant, its ability to fix Nitrogen is probably another reason for this tolerance. Nitrogen is most often the element limiting to plant growth. It is a constituent of chlorophyll, plant proteins, nucleic acid and other substances (Isirimah et al., 2003).

On the effect of crude oil on growth parameters of melon plant like: height, length and area of leaves and weight were not affected by oil treatment up to 0.5 % but higher levels reduced all the parameters significantly. Retardation of growth in higher levels of oil treatment than lower levels had been observed by Isirimah et al. (1989) and Ekpo et al. (2012), that plant height, dry matter yield and grain of maize were not affected by oil treatment of 1% but higher levels reduced all these character significantly and that the higher the quantity or concentration of the crude oil in the soil the

more effect it wiil have on germination and growth of plant. Isirimah et al. (1989), supported that crude oil pollution up to 1 % could easily be degraded by natural rehabilitation in soils as the oil could be expected to increase organic matter in the soil and improve the fertility, physical and chemical property of the soil. Previous studies cited above, have all shown that oil has adverse effects on plant growth. From this study, similar results have been observed where there were significant differences in growth between the untreated (control) and the treated plants. In the study also, it was observed that the the extent of retardation in growth was due to the concentration of crude oil applied, especially in melon plants.

In grounduts, plant height, length, area of leaves and weight were not affected by oil treatment up to 0.5 % but was mild in 2 % pots on the leaf areas. However, in the 5 % oil level, the effect was more significant than that of 2 %. The reason for the pronounced effect in groundnut with 5 % oil level, especially with time, may be due to the higher rate of coagulatory effect on the soil, binding the soil particles into water impregnable soil block which seriously impaired water drainage and oxygen diffusion (Gill et al., 1992). Oil usually causes anaerobic environment in soil by smoothering soil particles and blocking air diffusion in the soil pores (Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013). Previous studies by Rhykerd et al. (1998), Opeolu, (2000), Spiares et al. (2001), Odjegba and Sadiq (2002), Agbogidi and Nweke (2005), Kelechi et al. (2012), noticed a significant reduction in height of seedlings, leaf length and number of leaves for all levels of treatment relative to the control. These were also in agreement with this study but mainly with the melon and at 5 % oil level in groundnut. However, Ogbo (2009), obsercved that rice (Zea mays L) and groundnut (Arachis hypogeal) have more potentials for use in phytoremediation of oil contaminated soil which this study also agreed with because of the high tolerance of groundnuts in high level of crude oil polluted soil. The reason for the tolerance of groundnuts seedlings with increase in oil levels of up to 5 % was probably due to their adaptive significance and the ability to fix nitrogen in the top layer of the soil.

Correlation studies on germination,emergence and growth parameters revealed that crude oil significantly affected ($P<0.05$) the germination rate of melon and groundnuts at different pollution levels throughout the periods. Ther relationship was direct in groundnuts as increase in crude oil levels led to increase in germination while in melon there was inverse (negative) relationship as increase in oil levels led to a decrease in germination.

The correlation on plant heights (height/length of stem) revealed that there were significant differences ($P<0.05$) throughout the period in melon and groundnuts except in groundnuts 2 WAP where there was none. There was an inverse (negative) relationship on both plants showing a decrease in height of both plants with increasing crude oil levels in all but the effect was more on melon. The same scenario was also observed in leaf length and leaf area only that in this case, there was no exception. Crude oil significantly affected ($P<0.05$) the leaf length and leaf area in all and throughout the period. These findings are in areement with the previous report of Isirimah et al. (1989); Rhykerd et al. (1998), Opeolu (2000), Spiares et al. (2001), Odjegba and Sadiq (2002), Agbogidi and Nweke (2005) and Kelechi et al. (2012).

Although the general conclusion in literature on the effect of oil on soil is that it is beneficial at a very low concentration but detrimental at higher concentration, which this study also confirmed; in this study, 0.5 % oil level was considered as the upper safe level. According to Isirimah et al. (1989), whose report supported that about 2 % oil (by weight) in soil, imposes serious detrimental effect on agronomic crops and seeds and that complete elimination of growth resulted from 3.3 % oil (by weight) in soil. This study however reveals that the effect of 2 % and above 3.3 % oil level (by weight) as supported by Isirimah et al. (1989), are not for all agronomic crops and seeds. Our data support the report only on melon seeds and seedlings and not in groundnut seeds and seedlings because the groundnut seeds and seedlings in soil with 2 % oil levels germinated though not all and grew very well while those in soil with 5 % oil levels, had all their seeds germinated and grown well until they began to have a mild effect which increased with time.

6. CONCLUSION

From the data obtained in this study, the following conclusion can be made:

1. Crude oil has significant effect (positive or negative) on the germination and growth, of melon and groundnut
2. That crude oil of 2 % and above has a detrimental effect on melon germination and growth.
3. That Groundnut seeds and seedlings have a high tolerance rate in soil with crude oil pollution of up to 5 % oil levels.
4. That increase in crude oil level binds soil particles together into water impregnable soil block which impaires water drainage and oxygen diffusion.
5. That groundnut seed/seedling withstands the crude oil pollution than melon hence the effect of the pollution was higher in melon than the groundnuts

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REFERENCES

1. Adam, G. and Duncan, H. (2002). Influence of Diesel fuel on seed Germination. Environmental Pollution, 120 (2), 363-370.
2. Adewole, M. G. and Adenuga, M. (2002). Effect of crude oil on the Emergence and growth of cowpea in two contrasting soil types for Abeokuta Southern Western Nigeria. Asian Journal of Applied Sciences, 5, 232-239.
3. Agbogidi, O.M and Nweke, F.U. (2005). Effect of crude oil on the performance of Okra (Aboemoschus esculentus, L). Moench in Delta state. Africal Journal of Natural Science, 8, 31-36.
4. Agbogidi, O. M., Eruoter, P.G., Akparob, I. S.D. and Nnaji, G.U. (2007). Evaluation of crude oil contaminated soil on the minerial nutrient elements of maize (Zea mays. L). Journal of Agromony, 6 (1), 188-193.
5. Aislabe, J.M., Balks, M.R., Foght, J.M. and WaterHouse, E.J. (2004). Hydrocarbon spill on Antartic soil: Effect and management. Environmental Science and Technology, 38 (5), 1265-1274.
6. Akujuru, V.A. (1992). The professional duty of the valuers in oil pollution. Compensation Valuation, 2 (1) , 1-12.
7. Amadi, A.A, Dickson, A. and Moate, G.O. (1993). Remediation of oil polluted soil: Effect of organic nutrient supplement on the performance of maize (Zea mays, L). Water, Air Soil Pollution, 66, 59-76.
8. Anoliefo, G.O. (1991). Forcados blend crude oil effect in respiration, metabolism, elemental composition and growth of Citrullus Vulgaris (Schrad). PHD. Thesis. Benin. pp. 6-30.
9. Anoliefo, G.O. and Vwioko, D.E. (1994). Effects of spent lubricating oil on the growth of Capsicum annum.(L.) and Lycopersicon esculentum (Millet). Environmental Polluution, 88, 361-364.
10. Arocena, J.M. and Rutherford, P.M. (2005). Properties of Hydrocarbon and salt contaminated flared pit soil in northeastern British Columbia (Canada). Chemosphere, 60 (4), 567-575.
11. Association of official Analytical chemist. (1990). Official methods of analysis, 14th Edition. Washington D C.
12. Benneth, P.C., Siegel, D.E., Baedecker, M.J and Hull, M.F.(1993). Crude oil in a shallow sand and gravel aguifer -I. Hydrogeology and inorganic geochemistry. Applied Geochemistry, 8 (6), 529-549.
13. Bob-Manuel, K. D. H. and Johnson, K.T. (2001). Oil Spill clean-up techniques for sustainable environmental protection in the Niger Delts. NSE Technical Transaction,12 (36), 2.
14. Cambel, W.J. and Vavrik, M.C. (1990). Development of an emergence index of sensitivity to applied oil (year 2). Lousiana Applied and Educational Oil Spill Research and Development Program. OSRADP Technical Report Services No. 99-001.
15. Catalogue of Petroleum oil spill in Nigeria's Niger Delta (A study of continuous oil spill in the Niger delta). Urhobo Historical Society, ERA report-19998, 1999, 2000, 2001, 2002. http://www.waado.org. Retrieved on the 11th February, 2014.
16. CNN, (2010). BP rig explosion of April 20th, 2010.
17. Deborjit, B. and Sarada, K. S. (1996). Impact of crude oil pollution on plant Species number and live standing herbaceous crops biomes.The Environmentalist, 4 (16), 291-295.
18. Ekpo, I. A., Agbor, R.B., Okpako, E.C. and Ekanem, E.R. (2012). Effect of crude oil polluted soil on germination and growth of soybean (Glycine max). Annual Biological Research, 3 (6), 3049-3054.
19. Ekundayo, E.O. and Obuekwe, C.O. (1997), Effect of an oil spill on soil physico- chemical parameter of a spill site in a Typic Paleudult of Midwestern Nigeria. Environmental Monitoring and Assessment, 45 (2), 209-235.
20. Ekundayo, E.O. and Obuekwe, C.O. (2000). Effect of an oil spill on soil physico- chemical parameter of a spill site in a Typic udisampment of the Niger delta basin of Nigeria. Environmental Monitoring and Assessment, 60 (2), 235-249.
21. Ekundayo, E.O, Emede, T.O and Osayande, D.I. (2001). Effects of crude oil spillage on growth and yield of maize (Zea mays. L) in soil of Mid-Western Nigeria. Plant Foods and Human Nutrition, 56, 313-324.
22. Ekweozor, I.K.E. (1996). A review of the effects of oil pollution in a West African Environment. Discovery and Innovation, 1 (30), 27-37.
23. Federal Environmental Protection Agency. (1988). Federal Environmental Protection Agency Decree 1988.
24. Gabriel, A.O. (2004). Woman in the Niger Delta: Environmental issues and challenges in the third millenum. www.jsdafrica.com. Retrieved on the 25th September, 2014.
25. GESAMP, (1988). Impact of oil pollution on the marine environment. Report Studies Group of Expert on the Scientific Aspect of Marine Pollution, 6, 250.
26. Gbadegesin, A. (1997). The impact of oil exploration and production activities on the environment: Implications for peasant agriculture. Seminar paper on Oil and the Environment, organized by Frederick Ebert Foundastion in Port Harcourt.
27. Gill, L. S, Nyawuame, H.G.K. and Ehikhiametalor, A.O. (1992). Effects of crude oil on the growt and

anatomical features of Chromolaena odorata L. Newsletter, 5, 46-50

28. Isirimah, N.O. (2000). Soil and Environmental pollution management.Chapter1. Luton press ltd, owerri.
29. Isirimah, N.0., Zuofa, k. and Logannathan, P. (1989). Effect of crude oil on maize performance & soil chemical properties in the Humid forest zone of Nigeria. Discovery and Innovation, 1 (3), 95-98.
30. Isirimah, N.O., Dickson, A.A. and Igwe, C. (2003). Introductory soil chemistry & biology for Agriculture & Biotechnology. Osia Int'l Publishers, Port Harcourt.
31. Iuatimilehin J.C. (1992). The Ecological Impact of the Oil Industry in the Niger area of Nigeria (unpublished). pp 5-20.
32. Jaja, E.T., Ikpe F.A., Akani, N.P., Oboh, C.A. and Banigo, E.B. (1998). Long term effect of oil pollutionon some food components of Arachis hypogea. Niger Delta Biologia, 2 (2), 44-147.
33. Kadafa, Adati Ayuba. (2012). Environmental impacts of oil Exploration and Exploitation in the Niger Delta of Nigeria. Global Journal of Science Frontier Research. Environment and Earth Sciences, 12 (3), 1-10.
34. Kelechi, K.N.; Modukpe, S.A. and Temitope O.B. (2012). African Journal of Environmental Science and Technology,6 (1), 67-71.
35. Khamehchiyan, M, Hussein, C. A., Tajik, M. (2007). Effect of crude oil contamination on geotechnical properties of clayed and sandy soils. Engineering Geology, 89 (3), 220-229.
36. Labud, V., Garcia, C. and Hermanderz, T. (2007). Effect of hydrocarbon pollution on the Microbia properties of a sandy soil and clay soil. Chemosphere, 66 (10). 1863-1871.
37. Odjegba, V.I and Sediq, A.O. (2002). Effects of spent engine oil on the growth parameter, chlorophill and protein of Amaranthus hybids. L. Environmentalist, 22, 23-28
38. Ogbo, E.M. (2009). Effect of Diesel contamination on seed germination of four crop plants- Arachis hyposea, Vigna unguiculata, Sorghun bicolor and Zea may. African Journal of Biotechnology, 8 (2), 250-253.
39. Ogbonna, Peter Ejiomofor. (2013). Flora habits and seed production Characteristics in Egusi melon (Colocynthis citrillus L.). Journal of Plant Breeding and Crop Science.(Academic Journal) 5 (6), 137-140.
40. Olujimi, J.A.B., Adewumi, E.I. and Odunwole, S. (2011). Environmental implication of oil exploration and Exploitation in the coastal region of Ondo state, Nigeria: A regional planning appraisal. Journal of Geography and Regional Planning, 4 (3), 110-121.
41. Omoruyi, S.A., Orhue, U.X., Akerobo, A.A. and Aghimien, C.I. (1999). Prescribed Agricultual science for senior secondary school. Idodo publishers ltd, Benin-City.
42. Opeolu, B.O. (2000). Effect of lead on the performace and nutrient quality of two cowpea varieties. M.S.C thesis, Department of Crop Petroleum and Environmental Biology, University of Ibadan, Nigeria.
43. Raji, A. Y. and Abejide, T. S. (2013). Shell D'arcy Exploration and the discovery of oil as important foreign exchange earnings in Ijaw Land of Niger Delta, (1940-1970). Arabian Journal of Business and Management Review (OMAN chapter), 2 (11), 22-33
44. Rhykerd, R.L., Sen, D., Micinesse, K. J., and Weaves, R.W. (1998). Volatilization of crude oil from soil amended with bulking agents. Soil Science, 163, 87-92
45. Roy. J.L., Mcgill, W.B., Rawluk, M.D. (1999). Petroleum residues as water repellant substances in weathered non wettable oil contaminated soils. Canadian Journal of Soil Science, 79 (2), 357-380.
46. Spiares, J.O., Kenworthy, K.E. and Rhykerd, R.L. (2001). Emergence and height of plant seeded in crude oil contaminated soil. Texas Journal of Agriculture and Natural Resources, 19, 37-46
47. Sutton, N.B., Maphosa, F. and Morillo, J.A. et al., (2013). Impact of long term diesel contamination on soil microbial community structure. Applied and Environmental Microbiology, 79 (2), 619-680.
48. Tarek, Youssef (2001). Evidence for reduce post spill recovery by the halophyte Sporobulus iocladus in oil contaminated sediment. Marine Bulletin, 44 (4), 334-339.
49. Tolulope, A.O. (2004). Oil exploration and environmental degredation: The Nigerian Experience. International Information Archives, 2, 387-398.
50. Townsend, G.T., Prince, R.C., Suflita, J.M. (2003). Anaerobic oxidation of crude oil hydrocarbons by the residual micro organism of a contaminated soil anoxic aquifer. Environmental Science and Technology, 37 (22): 5213-5218.
51. Ubong, I.U. and Gobo, A. (2001). Fundamentals of Environmental Chemistry and meteorology. Tom and Harry publisher ltd, Port Harcourt.
52. Udo, E.J., Ibia, T.O., Ogunwale, J.A., Ano, A.O, and Esu, I.E. (2009). Manual of Soil, Plant and Water Analysis. Sibon Books Limited, Lagos.
53. Ukoli, M.K. (2005). Environmental factors in the management of the oil and Gas industry in Nigeria. www.cenbank.org. Retrieved on the 20th January, 2015

54. United Nations Development Program (UNDP). (2006). pp:185-186. Niger Delta Development Report Abuja, Nigeria
55. Uzoho, B. U., Oti, N.N. and Onweremadu, E. U. (2004). Effect of crude oil pollution on Maize growth and soil properties in Ihiagwa,Imo State, Nigeria. International Journal of Agriculture & Rural Development, 5, 91-100.
56. Wang, Y., Feng, J., Lin, Q., Wang, X., Lyu, X. and Wang, G. (2013). Effect of crude oil contaminationn on soil physical and chemical properties in Momoge wet land of China. Chinese Geographical Science, 6, 708-715
57. Wiltse, C.C., Rooney, W.L., Cheng, Z., Schwab, A.P. and Banks, M.K. (1998). Green house evaluation of agronomie and crude oil phytoremediation potential among alfalfa (Medica sativa.L) genotypes. Journals of Environmental Quality, 27 (1), 169-173.
58. Worgu, S.O. (2000). Hydrocarbon Exploration, Environmental Degradation and Poverty in the Niger Delta Region of Nigeria. http://www.waado.org/environment/petrolpollution /EnvEconomics htn. Retrieved on the 25th September, 2014