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Growth and performance of some edible legumes cultivated in Crude Oil impacted Nigerian Niger Delta soil

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ABSTRACT

A 3-months ecological study was conducted to determine the effects of crude oil on vegetation growth in the Niger Delta region of Nigeria. Crude oil had significant ($p \leq 0.05$) adverse effects on water infiltration, vegetation regeneration, root length and the accumulation of plant biomass. The vegetation heights at the polluted sites were 44 ±5cm against 136 ±20cm and 3.9 ± 0.4cm and 13.9 ± 2.8cm for Sphenostylis stenocarp a and Vigna subterranea respectively in comparison to the unpolluted sites. Up to 641 mg/kg total petroleum hydrocarbons, TPH were seen in the shoot tissues and 22mg/kg in V. subterranea and S. stenocarpa respectively while good percentages of hydrocarbon degradation were recorded for V. subterranea . Stress responses by the leaf tissue were measured by the leaf area, LA. Other growth indices monitored presented V. subterranea as more tolerant specie. Phytotoxic responses were observed and recorded. The implications of these results for the enhancement of environmental quality and Agriculture within the study area are discussed.

Key words: Contamination; Legumes; Spill; Degradation.

INTRODUCTION

Soil contamination comes from various human activities, including intensive agriculture (phosphate fertilisers), sewage sludge dumping and exploration activities. Petroleum is a complex mixture that contains thousands of different compounds. Successful oil direct and indirect effect involves appropriate sampling, analytical approaches and data interpretation strategies (Römkens et al., 1999). The uptake of elements by plants depends on the availability of the element, the pH of the media, interactions with other elements, and the species of plant,

among other factors (López et al., 2009; Nwaichi et al., 2010; Johnson, 2006). An impressive volume of literature exists on large scale environmental pollution in relation to the wild but relatively little has been documented on environmental degradation as regards agricultural species.

This study seeks to determine the short-term effects of crude oil on vegetation regeneration, adaptability and other agricultural functions. Information on this aspect of an important and relatively ubiquitous small scale agricultural set up in the country is of importance for any national holistic strategy to enhance the quality of the nation's environment and possible biomagnifications of contaminants.

MATERIALS AND METHODS

Site description:
The study site is located at Choba in Obiakpor LGA of Rivers State, Nigeria. The soil was spiked in April 2009 and the post impact period was only two weeks after which cultivation commenced.

Field reconnaissance and sampling design:
Sampling was carried out as part of field reconnaissance survey. Triplicate surface soil samples (0-15cm depth) were collected using a clipped quadrat technique in a stratified random sampling design. The soil samples were put in aluminum foil bags and labeled accordingly.

Table 1 TPH (mg/kg) content of *V. subterranea* soil (S) samples State (Data represents means± SD from triplicate samples). CTRL, CON, PRE-P and TMT signify control experiment, contaminated soil after harvest, contaminated soil before planting, and treatment respectively. 2, 4, 6, 8, and 10 appended to S represent 5 spill concentration (w/v) simulated.

TMT	CTRL	CON	PRE-P
S2	904a±1.53	2244b±4.93	3011e±6.08
S4	904a±1.53	2430b±17.3	3787f±10
S6	904a±1.53	2500b±57.7	4302g±115
S8	904a±1.53	3020e±5.78	5001i±58
S10	904a±1.53	3241e±10	5613j±5.8

5g of homogenized soil samples were accurately weighed into clean, dry beakers. The weighed samples were extracted with 10ml of hexane respectively and passed through a filter paper. The extract (the hydrocarbon/hexane mix), now ready for gas chromatography, was injected into a Varian model 3400 gas chromatograph (GC) with the following operational conditions; low rate (H_2 30ml/min, air 300ml/min, and N_2 30ml/min); injection temperature (50^0C), detector temperature (320^0C); recorders' voltage (IMV); and chart speed 1cm/min. For interpretation of results, the GC recorder was interfaced to a Hewlett Parker (hp) Computer (6207AA Software, Kayak XA PIT/350 W/48 megabytes CD-ROM). The chromatograms were quantified with respect to the internal standards.

Statistical analysis:
Statistical Package for Social Sciences for Windows version 10.0 (SPSS Inc., Chicago, IL) was used to perform one – way analyses of variance and the pearson correlation. Pairs of treatment means were compared for significant differences using least significant difference (LSD) at the 5% level.

Table 2 TPH (mg/kg) content of *V. subterranea* shoot (L) samples State (Data represents means± SD from triplicate samples). CTRL, CON, PRE-P and TMT signify control experiment, contaminated soil after harvest, contaminated soil before planting, and treatment respectively. 2, 4, 6, 8, and 10 appended to S represent 5 spill concentration (w/v) simulated.

TMT	CTRL	CON
L2	26n±0.3	41l±6
L4	26n±0.3	42l±0.6
L6	26n±0.3	52.3l±3
L8	26n±0.3	54l±3
L10	26n±0.3	64l±6

Table 3 TPH (mg/kg) content of *S. stenocarpa* soil (S) samples State (Data represents means± SD from triplicate samples). CTRL, CON, PRE-P and TMT signify control experiment, contaminated soil after harvest, contaminated soil before planting, and treatment respectively. 2, 4, 6, 8, and 10 appended to S represent 5 spill concentration (w/v) simulated.

TMT	CTRL	CON	PRE-P
S2	889a±1.53	2477b±5.50	3011f±6.08
S4	889a±1.53	2980f±6.08	3787g±1
S6	889a±1.53	3268h±5.51	4302i±1.15
S8	889a±1.53	3480h±5.78	5001k±0.58
S10	889a±1.53	3800g±0.58	5613k±0.58

Table 4 TPH (mg/kg) content of *S. stenocarpa* shoot (L) samples State (Data represents means± SD from triplicate samples). CTRL, CON, PRE-P and TMT signify control experiment, contaminated soil after harvest, contaminated soil before planting, and treatment respectively. 2, 4, 6, 8, and 10 appended to S represent 5 spill concentration (w/v) simulated.

TMT	CTRL	CON
L2	10.3m±3	21m±3
L4	10.3m±3	21.2m±3
L6	10.3m±3	21.3m±2.8
L8	10.3m±3	21.1m±3
L10	10.3m±3	22m±3

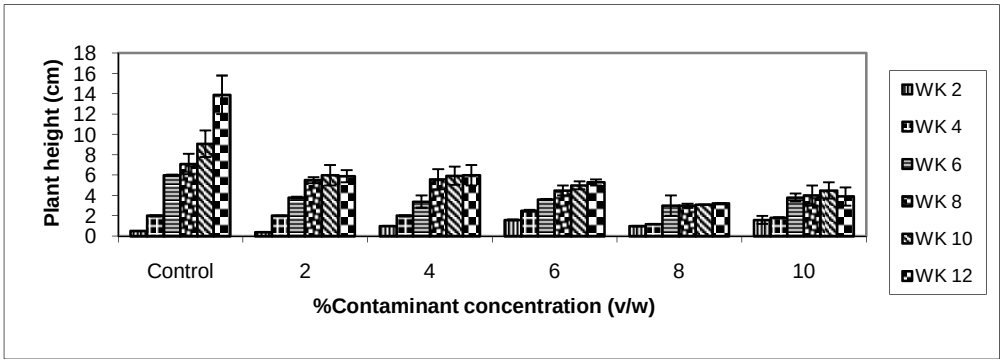

Fig 1 Vegetation (*Vigna subterranea*) height (cm) at control and crude oil polluted regimes in the Choba area of Rivers State (Data represents means± SE from triplicate samples).

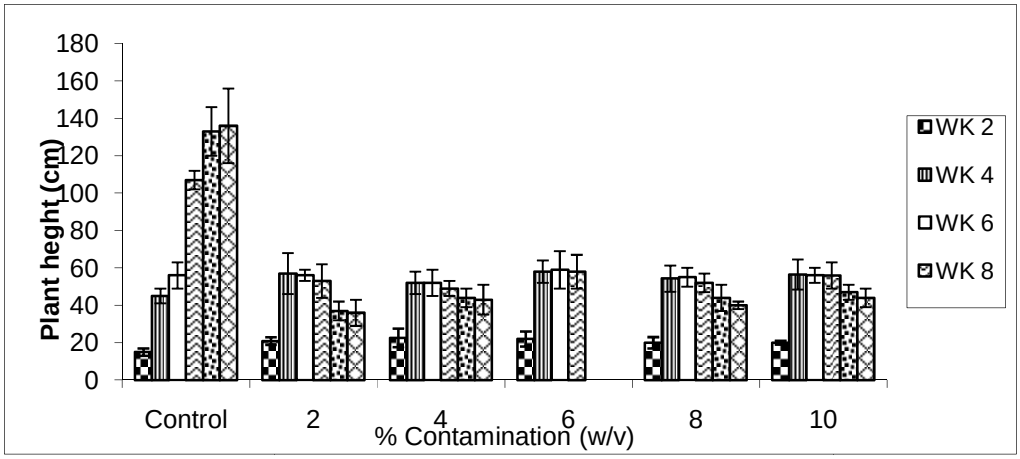

Fig 2 Vegetation (*Sphenostylis stenocarpa*) height (cm) at control and crude oil polluted regimes in the Choba area of Rivers State (Data represents means± SE from triplicate samples).

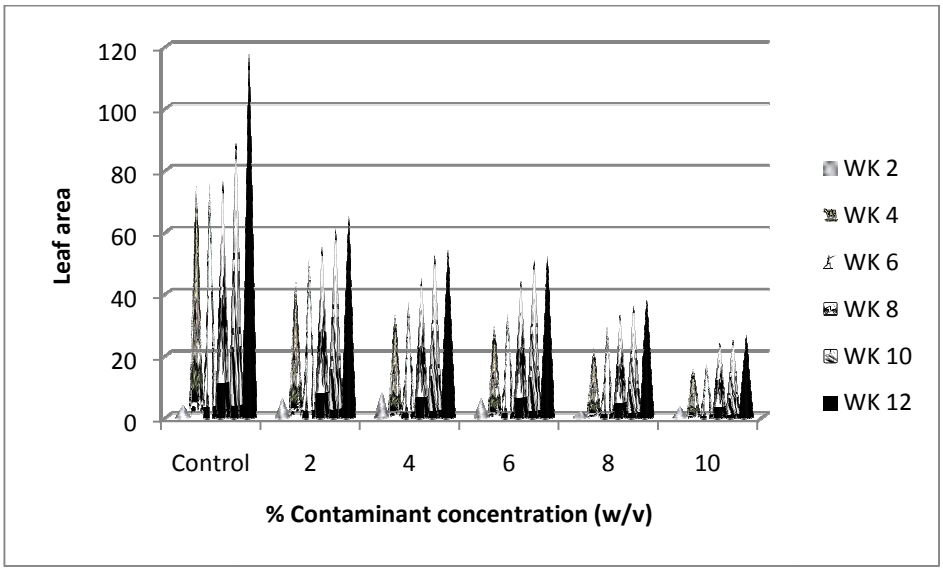

Fig 3 Vegetation (*Vigna subterranea*) leaf area at control and crude oil polluted regimes in the Choba area of Rivers State.

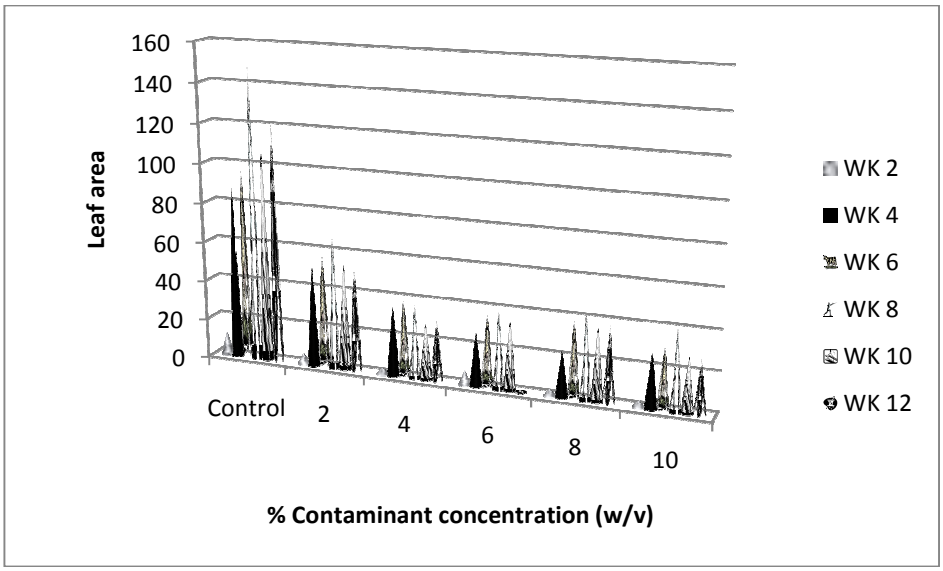

Fig 4 Vegetation (*Sphenostylis stenocarpa*) leaf area at control and crude oil polluted regimes in the Choba area of Rivers.

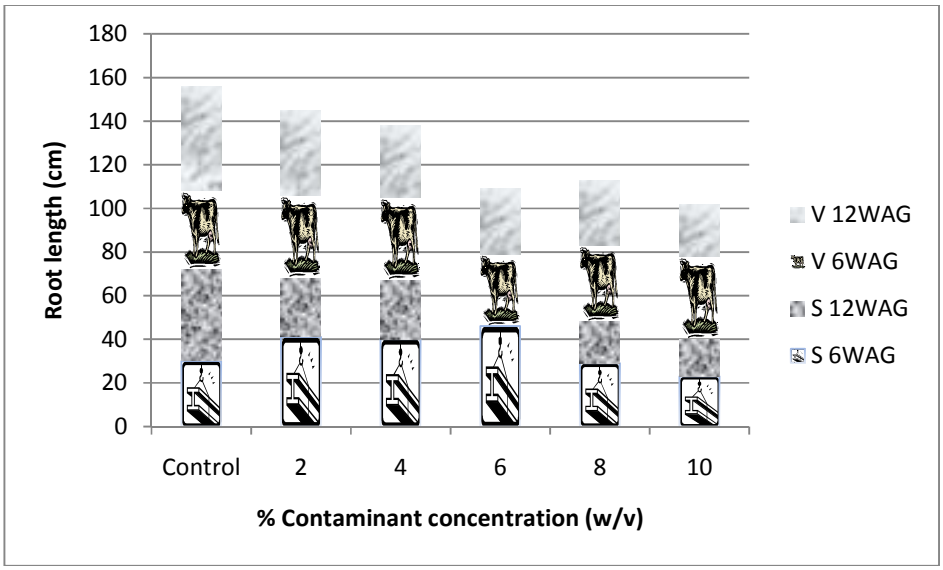

Fig 5 Observed Root length at 6 and 12 weeks after germination (WAG) for *S. stenocarpa* (S) and *V. subterranean* (V)

RESULTS AND DISCUSSION

The effect of crude oil on these common edible species in Nigeria was relatively severe as was seen in various phytotoxic responses observed. Plant production was reduced due to the action of contaminants in lowering the fertility of contaminated soils and decreasing nutrient uptake by roots. The total petroleum hydrocarbon, TPH content of the soil decreased from 5613 mg/kg to 3241 mg/kg and 3800 mg/kg for *V. subterranea* and *S. stenocarpa* respectively (Tables 1 and 2)

after the 3 months of cultivation indicating different degradation efficiencies.. Observed TPH levels accumulated in the shoot tissues were presented in Tables 3 and 4 and showed an upwards trend with contaminant concentration especially with those observed for *V. subterranea.* At the end of the 12-week study, the biomass depreciated at the polluted sites (data not shown). Vegetation height at the control and unpolluted sites was 7.02±0.28cm as against only 4.16±0.45cm at the polluted sites at the highest dose of the contaminant (Figures 1 and 2) and was statistically different from those of the control experiment. The crude oil pollutant thus retarded plant growth (height) by 40.74% which is significant at p = 0.001. At all concentrations mimicked, *V. subterranea* survived the 12-week studies while *S. stenocarpa* never survived beyond week 8 at 6 % (w/v) oil contamination. There were no marked variations between tested spill concentrations in relation to observed leave area for both species (Figures 3 and 4). From figure 5, root length suffered significantly with time going from six weeks after germination (6WAG) to twelve weeks after germination (12WAG) for *S. stenocarpa* in comparison to control. On the other hand, *V. subterranea* compared favourably with control except at the 10 % (w/v) oil contamination.

Elevated contaminant concentration accelerated senescence evident in early fruition at the highest contaminant dose and reduced the duration of viable leaf area. This is in consonance with the findings of Mullarkey and Jones (2000). The period of imbibition resulted in synchronization of seed germination; because stress sensitivity increases as dormancy ends. Also, the degradation process as depicted by the trend in the disappearance of low-molecular-weight hydrocarbons from the chromatograms first (chromatograms not shown), due to their preferential consumption by the microorganisms provides adequate information on the changes taking place during the degradation process (Udoetok and Osuji, 2005). The trend developed as a result of the disappearance of these hydrocarbon fractions from the chromatograms can then be employed in oil spilled source identification as no two oils will exhibit the same fingerprints. Plant age is important in tolerance studies due to the varying sensitivity of the plant at different growth stages (Robert and Susan, 1983). Exposing plants to high temperatures at early stages (e.g. sudden rise in temperature with crude oil application), can affect factors such as node extension and ear development, while temperature stress at anthesis and later can cause premature leaf senescence and can affect the fertility of the plant leading to reduced grain development as was obtained in this study.

The study shows that crude oil can induce significant adverse effects on the structure and functions of terrestrial ecosystems. Also, *V. subterranea* presented itself as a more oil-stress tolerant specie in conmparison to *S. stenocarpa*. Generally, the inhibitory effect of oil stress on plant viability was reflected in declines in growth parameters monitored.

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