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RESEARCH ARTICLE

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Effect of crude oil polluted soil on the growth and survival of pepper (*Capsicum annuum* L.)

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ABSTRACT

The effect of crude oil on growth and survival of Capsicum annuum was investigated in Ahmadu Bello University, Zaria. Planting was done in polythene bags measuring (60 x 25x 15cm) and each bag was filled with 15kg of top soil (0-15m depth) collected from Ologbo flow station, Benin City. Two polythene bags per crude oil concentration were replicated thrice in a randomized block design which made a total of 18 bags. Treatment of the soil was carried out by weighing the concentration of crude oil ranging from MI (75% unpolluted soil + 25% crude oil polluted soil) and HI (50% unpolluted soil + 50% crude oil polluted soil) into soil samples contained in polythene bags. Each concentration of polluted soil was thoroughly mixed using hand trowel. Six seedlings of Capsicum annuum were planted into each of the soil sample treated with varying concentrations of crude oil resulting in a total of 108 seedlings. The result indicated that crude oil pollution significantly reduced ($p < 0.05$) the growth of the Capsicum plant at higher pollution rate than at lower pollution rate. This thus implies that the higher the quantity or concentration of the crude oil in the soil the more effect it would have on the growth and survival of Capsicum plant.

Key words: Capsicum annuum, Crude oil, effect, survival and growth.

INTRODUCTION

The discovery of oil as the world's leading fuel was partly due to its relative cleanliness but the enormous scale of the petroleum industry's operation has inevitably created a new set of difficult environmental problems as being experienced today in the Niger Delta region of Nigeria [1,2,3]. Crude oil is extracted in locations that are remote and transported in large quantity, for it to be refined and for the derivation of its useful by-products. Transportation of crude oil or its products from the point of production to that of processing has resulted in spillage with adverse consequences. The transportation method employed includes the use of oceanic tankers and pipelines overland. These transportation methods sometimes pollute the environment by accidental oil spills and operational discharge resulting to the loss of very large quantities of crude oil into land and sea bodies. One of the biggest concerns associated with petroleum pollution in the environment is the risk to farmland, fisheries, and potable drinking water contamination since most of the people's livelihood depends on farming, fishing and usage of water for their domestic purpose [4] Spillage of crude oil on soil makes it unsatisfactory for plant growth as a result of insufficient aeration of the soil as air is displaced from the spaces between the soil particles by crude oil [5]. Any change in the biological, chemical and physical composition or environment of soil affects the growth and productivity of crops [6-9] As a result of the increasing economic crisis and highly dependence on arable crops such as pepper (*Capsicum* *annuum*) to both the generation of income and meetings of human need at large, this research is aimed at ascertaining the survival and growth rate of pepper (*Capsicum annuum*) on crude oil polluted soil.

MATERIALS AND METHODS

The seeds of *C. annum* L. were obtained from the Agricultural Development Project, Benin City, Edo State, Nigeria while the crude oil polluted soil used in this study was obtained from the dumpsite at Oredo Flow Station field of the Nigerian Petroleum Development Corporation (NPDC), Ologbo, Benin City on the 11th of November, 2011. The seeds were identified and the viability of the seeds was determined using the chemical viability test. The *Capsicum* seeds were nursed for three (3) weeks in the screen house of Biological Sciences, Ahmadu Bello University, Zaria. The seedlings (3 weeks of age) of *C. annum* L. were transplanted into polythene bags weighing 15kg of soil with a spacing of 1m on the row and 1m between rows in a randomized block design and monitored during the rainy and dry season respectively. The different concentration of soil samples obtained was divided into heavily impacted soil (HI) (50% unpolluted soil + 50% crude oil polluted soil), medium impacted soil ((MI) (75% unpolluted soil + 25% crude oil polluted soil) and control (C) per weight. Each concentration was thoroughly mixed using a hand towel. There were three (3) treatments and three (3) replicates and each replicates contained 12 seedlings making a total of 108 seedlings of relatively equal age. The survival rate of number of seedlings that survived from each plastic bag was summed up after seven days. The survival rate of each treatment was calculated thus;

$$Survival\ rate = \frac{No\ of\ seedlings\ that\ survived}{No\ of\ seedlings\ transplanted} * 100$$

Data collection

Observations on growth and morphology were made at 1week intervals in which the following parameters such as Survival rate, Plant height, Leaf area, Leaf Number Fresh and Dry weight matter were determined.

Plant height was obtained by measuring the plant from the soil level to the collar of the uppermost leaf. The leaf area was determined by measuring the length and width (at the widest point) of each leaf. The product of this was multiplied by a correction factor of 0.75 to cater for leaf shape [10]. The leaf number was done by counting manually and the yield observed was counted after harvesting. The plant samples were oven dried using the Memmert oven at 70°C for 22hour to a constant weigh t using the method of Ekpo and Ebeagwu [11] to get the dry weight matter. This was done for both the dry and rainy season. The germination rate was computed after five (5) days and ten (10) days respectively.

Experimental design/ Statistical analysis

The experiment was arranged in a Randomized Completely Block Design (RCRD), and data collected were subjected to analysis of variance (ANOVA) test while the means were separated using least significant difference (LSD) test.

RESULTS

The result obtained shows that significant differences ($p<0.05$) exist between the various concentration of crude oil used for the experiment during the six weeks rainy and dry season data study period.

Survival rate: The result on the days to seedling survival rate showed that they were significant difference ($P< 0.05$) in the survival rate of the *Capsicum* plant as compared with the control, implying that crude oil affected the survival rate of *C. annuum* at the concentrations used for the study.

Plant Height: *Capsicums* was more or less constant initially after transplanting until the 2-4WAT. Significant difference ($P< 0.05$) was observed when plants in the MI soil began to gradually increase in plant height while those in the HI soil has stopped increasing in height 3-6WAT until plant eventually dried up (Table 1 and 2) in both seasons.

Leaf Number: It was observed that there were significant differences in the leaf number. Crude oil pollution at 3WAT and 6WAT at all concentrations resulted in a significant reduction in leaf number when compared with the control ($p<0.05$). 2WAT in the various levels of concentrations, there was an exponential increase in leaf number of MA and HA at both season respectively (Table 3 and 4), thereafter no increase till the end of the experiment.

Leaf area: At all concentration 3WAT and 5WAT resulted in a significant reduction in leaf area when compared with the control ($p<0.05$) during the rainy season. At the end of the experiment, crude oil pollution significantly reduced total leaf area with increased intensity (MI<HI) when compared with control in the two species of Capsicum at both seasons (Table 5 and 6).

Plant fresh weight: The fresh weight of both Capsicums varies between the various levels of concentrations and between both seasons. Data obtained for plant fresh weight has showed significant differences between the control (CA), and the various level of crude oil pollution (MA and HA). The highest values were obtained in the control 2 – 6WAT during the rainy season while the least values were obtained in HA 4WAT in the crude oil polluted soil (Table 7 and 8).

Plant dry weight: The difference observed in the plant dry weight on various treatments was also observed to be significant. 5 – 6 WAT at all concentrations result ed in a significant reduction in plant dry weight when compared with the control ($p<0.05$) during the rainy season (Table 9). Although, Crude oil polluted 1 WAT had no significant difference at all levels of pollution compared with the control, 2 – 6WAT showed significant reduction in MA, and HA as compared to control (CA) during the dry season (Table 10).

Table 1: Mean plant height during the rainy season

Crude oil Concentration	**Weeks after Transplanting (WAT)**					
	1	2	3	4	5	6
CA	8.32 ± 0.27^{a}	10.12 ± 0.55^{a}	11.45 ± 0.58^{a}	16.40 ± 1.09^{a}	22.98 ± 1.28^{a}	27.03 ± 1.19^{a}
MA	8.20 ± 0.66^{a}	8.42 ± 0.65^{b}	8.53 ± 0.70^{b}	8.75 ± 0.66^{b}	8.18 ± 0.80^{b}	7.40 ± 0.45^{b}
HA	7.80 ± 0.43^{a}	7.95 ± 0.41^{bc}	7.87 ± 0.53^{bc}	7.80 ± 0.54^{bc}	7.32 ± 0.27^{bc}	7.37 ± 0.39^{b}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 2: Mean plant height during the dry season

Crude oil Concentration	**Weeks after Transplanting (WAT)**					
	1	2	3	4	5	6
CA	8.00 ± 0.51^{a}	8.80 ± 0.64^{a}	10.38 ± 0.39^{a}	11.38 ± 0.64^{b}	11.20 ± 0.75^{b}	14.48 ± 0.98^{a}
MA	6.90 ± 0.37^{b}	7.00 ± 0.40^{b}	6.83 ± 0.45^{b}	6.75 ± 0.22^{c}	6.70 ± 0.29^{c}	6.70 ± 0.29^{b}
HA	7.02 ± 0.38^{b}	7.25 ± 0.60^{b}	6.52 ± 0.38^{b}	5.83 ± 0.49^{c}	5.30 ± 0.61^{d}	5.30 ± 0.61^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 3: Mean Leaf number during the rainy season

Crude oil Concentration	**Weeks after Transplanting (WAT)**					
	1	2	3	4	5	6
CA	4.50 ± 0.22^{a}	6.00 ± 0.37^{a}	8.00 ± 0.58^{a}	13.00 ± 1.86^{b}	20.33 ± 2.85^{a}	26.00 ± 3.70^{a}
MA	5.33 ± 0.33^{a}	5.17 ± 0.31^{b}	4.00 ± 0.26^{b}	3.33 ± 0.33^{cd}	3.33 ± 0.33^{b}	3.17 ± 0.31^{b}
HA	1.85 ± 0.22^{b}	4.17 ± 0.40^{c}	3.00 ± 0.37^{c}	2.50 ± 0.34^{d}	2.50 ± 0.34^{bc}	1.83 ± 0.31^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 4: Mean Leaf number during the dry season

Crude oil Concentration	**Weeks after Transplanting (WAT)**					
	1	2	3	4	5	6
CA	5.50 ± 0.76^{a}	6.33 ± 0.92^{a}	6.50 ± 0.56^{a}	9.67 ± 0.76^{a}	15.00 ± 1.47^{a}	21.5 ± 2.02^{a}
MA	4.17 ± 0.40^{b}	4.00 ± 0.52^{b}	3.67 ± 0.33^{b}	3.50 ± 0.29^{b}	3.50 ± 0.29^{b}	3.50 ± 0.29^{b}
HA	4.33 ± 0.21^{b}	4.00 ± 0.26^{b}	3.33 ± 0.42^{b}	2.17 ± 0.54^{c}	2.17 ± 0.54^{c}	2.00 ± 0.41^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 5: Mean Leaf Area (cm^2) during the rainy season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	1.69±0.14^{a}	2.57±0.28^{a}	3.46±0.33^{a}	6.86±1.34 ^{a}	9.44±1.25^{a}	12.11±1.13^{a}
MA	1.89±0.19^{a}	1.93±0.23^{a}	1.89±0.19^{b}	1.50±0.20^{b}	1.16±0.25^{b}	1.04±0.35^{b}
HA	1.85±0.22^{a}	1.94±0.16^{a}	2.03±0.18^{b}	1.47±0.15^{b}	0.63±0.16^{c}	0.50±0.18^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 6: Mean Leaf Area (cm^2) during the dry season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	1.21±0.13^{a}	1.47±0.26^{a}	1.78±0.15 ^{a}	2.85±0.40^{a}	3.36±0.56^{a}	4.70±1.02 ^{a}
MA	1.05±0.14^{a}	1.05±0.14^{a}	1.09±0.14^{ab}	1.10±0.10^{b}	0.82±0.03^{b}	0.94±0.15^{bc}
HA	1.00±0.12^{a}	1.02±0.11^{a}	1.00±0.07^{b}	0.64±0.15^{c}	0.52±0.16^{b}	0.50±0.31 ^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 7: Mean plant fresh weight (g) during the rainy season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	0.16±0.05^{a}	0.31±0.04^{a}	0.78±0.05 ^{a}	1.05±0.13^{a}	1.84±0.25^{a}	2.67±0.25^{a}
MA	0.12±0.04^{a}	0.24±0.03^{b}	0.35±0.03^{b}	0.27±0.08^{b}	0.22±0.03^{b}	0.21±0.02^{c}
HA	0.13±0.02^{a}	0.17±0.03^{c}	0.28±0.04^{b}	0.17±0.04^{c}	0.15±0.04^{b}	0.12±0.01^{bc}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 8: Mean Plant fresh weight (g) during the dry season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	0.05±0.02^{a}	0.20±0.01^{a}	0.25±0.04^{a}	0.61±0.01^{a}	0.49±0.03^{a}	0.58±0.01^{a}
MA	0.04±0.03^{a}	0.12±0.02^{b}	0.14±0.01^{b}	0.19±0.02^{b}	0.17±0.02^{b}	0.10±0.004^{bc}
HA	0.05±0.004^{a}	0.07±0.04^{c}	0.07±0.01^{c}	0.15±0.003^{b}	0.13±0.03^{b}	0.07±0.01^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 9: Mean Plant dry (g) weight during the rainy season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	0.07±0.03^{a}	0.07±0.01^{b}	0.20±0.03^{a}	0.24±0.03^{b}	0.28±0.01^{a}	0.76±0.14^{a}
MA	0.02±0.01^{a}	0.03±0.01^{cd}	0.11±0.02^{bc}	0.07±0.01^{d}	0.05±0.02^{b}	0.04±0.^{01bc}
HA	0.02±0.01^{a}	0.02±0.003^{d}	0.08±0.03^{c}	0.04±0.01^{d}	0.03±0.003^{b}	0.02±0.01^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

Table 10: Mean plant dry (g) weight during the dry season

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
CA	0.06±0.01^{a}	0.08±0.03^{a}	0.11±0.01^{a}	0.23±0.03^{a}	0.11±0.01^{a}	0.18±0.02 ^{a}
MA	0.01±0.003^{a}	0.02±0.002^{b}	0.05±0.004^{b}	0.07±0.01^{b}	0.04±0.003^{b}	0.03±0.01^{b}
HA	0.01±0.001^{a}	0.03±0.004^{b}	0.04±0.01^{bc}	0.05±0.005^{b}	0.02±0.01^{b}	0.01±0.001^{c}

**Means (a, b, c represents mean variation) in the same column with same letter(s) are not significantly different (P≥0.05), CA = C. annuum in Control, MA = C. annuum in Medium polluted soil, HA = C. annuum in Heavily polluted soil, WAT = Weeks after transplanting*

DISCUSSION

The result revealed that the crude oil significantly affected (P>0.05) the survival rate of the *C. annuum* plant at the various crude oil concentration. However, the percentage survival rate at one week after transplanting revealed that 87%, 67.57% and 63.12% of seedlings survived in control, MI and HI crude oil polluted soil. One of the possible reasons for the mortality rate in crude oil polluted soil is due to the physical smothering by oil, which can lead to reduced transpiration, respiration and photosynthesis. Absorption of toxic oil fraction through the leaves or roots may also cause poisoning of the plant by disrupting cell membranes and cellular organelles [12].

The result on plant height which recorded no significant effect of the crude oil on the plant one to two weeks after transplanting showed that as the plant continued to grow on the polluted soil until 3-6WAT when the oil suffix thereby affecting the plant height. This resulted to significant reduction in plant height 3-6WAT in various crude oil polluted soil as compared to control. (Table 1 and2).

The reduction of plant growth observed in this study could be due to reduction of mineral element with increasing oil concentration in the soil. This findings is similar to that of Udo and Fayemi, [13] who observed similar effects of crude oil in corn (*Zea mays* L.) grown in crude oil polluted soil. This effect could also be as a result of reduced availability of mineral elements because according to Scwab and Banks [14] plant nutrition is based not only on the presence of mineral elements in the soil but their availability.

The result on leaf number also revealed that significant difference (P>0.05) exist between the control and the various crude oil pollution 2WAT at both season. The reduction in leaf number (Table 3 and 4) in this study is an indication that crude oil has a damaging effect on the leaf production as the number of leaves decreased with increase in crude oil pollution. This is in agreement with the findings of Egharevba and Osunde [15] who reported a decrease in leaf number as a result of leaf drop due to crude oil effect on *Dacryodes edulis* and *Crysophyllum aibidum*.

The result on leaf area also revealed that significant difference (P>0.05) exist at the different pollution level in 2WAT in crude polluted soil in the rainy season and 3WAT in crude polluted soil in the dry season (Table 5 and 6). The reduction of leaf area of the plants due to the addition of crude oil reduces the photosynthetic level in the plant with resultant poor performance of the plant. The reduction in the leaf area and leaf shrinkage of *C.annuum* in the polluted soil 3WAT in both seasons agreed with Baker [16], which was attributed to reduction in cell expansion due to contact with oil pollution . Similar results were also reported by Bargali and Bargali [17] for eucalypt species with the change in plantation age, season and soil nutrient levels.

The effect of crude oil on the fresh and dry matter weight of *C. annuum* plant showed that 1-3WAT, there were slight increase in weight and a gradual reduction in HA, in the dry season. However, there was significant difference (P>0.05) in the various crude oil polluted soil as compared with the control. Similar findings was also reported by Egharevba and Osunde [15] that there was decrease in dry weight of leaves, stems and roots in *Chrysophyllum albidum* and *Dacryodes edulis* as a result of crude oil pollution. Other effect range from disruption of plant water relations, direct impact to plant metabolism, for instance, nutrient uptake, toxicity to living cells for example the liquid component of the protoplasm, reduced oxygen exchange between the atmosphere and the soil affecting root function [18] to reduction in biomass.

CONCLUSION

The present study showed that crude oil polluted soil adversely affected the growth and survival of *C. annuum* plant at various concentration of treatment. Capsicum plants that survived in contaminated soils were stunted, chlorotic or leafless. This study has revealed that crude oil pollution has economic implication on growth of Capsicum plant and there is need to protect arable farmland from crude oil pollution.

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