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RESEARCH ARTICLE

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Seasonal variation of *Capsicum frutescens* L. (Chilli Pepper) to crude oil spill on soils from Ologbo, Edo State

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ABSTRACT

The effect of crude oil spillage on the growth performance of Capsicum frutescens L. (chilli pepper)was assessed in a polythene bag treated with 0 mL (control), MI (75% unpolluted + 25% crude oil polluted soil) and HI (50% unpolluted soil + 50% crude oil polluted soil) respectively. The various concentrations were arranged in a complete randomized block design duringthe rainy and dry season respectively. The plant height, leaf number, leaf area and chlorophyll determination were the parameter used for the study. Plant growth was retarded in both the MI and HI soil with the lowest values recorded in the HF 6WAT at both season. The results obtained on the growth rate of the Capsicum plant also showed a decrease in leaf number and leaf area values with increase in crude oil contamination. The leaf area was significantly reduced at 95% level of probability when compared with the control at 3WAT and 5WAT duringthe rainy and dry season respectively. Although there was insignificant difference in chlorophyll content in all treatment, however, symptoms such as chlorosis and leaf drop were observed at 3WAT. Hence, crude oil has a negative effect on the growth and survival rate of Capsicum plant.

Keywords: Capsicum; polluted soil; mortality; toxicity.

INTRODUCTION

The Niger Delta region of Nigeria is one of the world's largest wetlands and includes by far the largest mangrove forest in Africa. It can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests [1]. The Niger Delta covers 20,000 km^2 within wetlands of 70,000 km^2 formed primarily by sediment deposition. Transportation of crude oil or its products from the point of production to that of processing has resulted in spillage with adverse consequences. Oil blow outs have also occurred during extraction stage and when these happen, the oil empties itself either on the soil or in water bodies while the volatile one escape to the atmosphere. One of the biggest concerns associated with petroleum pollution in the environment is the risk to farmland [2]. Oil pollution has been a major source of concern to the people living in the crude oil-rich-areas [3]. Soil polluted with crude oil adversely affect the nutrient level and fertility status of the soil, thereby affecting the growth of agricultural crops [4]. Photosynthesis in plants can be affected directly through the alteration of cell membrane as a result of constant uptake of heavy metals into their system. The crude oil polluted soil creates an unsatisfactory condition for plant metabolism due to insufficient aeration brought about by an increase in oxygen demand by oil decomposing microorganisms. Plants and soil microbes compete for the little nutrient available in soils polluted with crude oil thereby suppressing the growth of plants in such soils. Omosun*et al* (2008) reported that plants are highly susceptible to oil exposure and this may kill them within a few weeks to several months [5]. The incessant occurrence of oil spill in the Niger Delta region of Nigeria right from the inception of oil boom revolution till date has been alarming. There has been series of spills from oil wells during exploration (drilling) and pipeline explosion during transportation to substations due to excessive pressure and malfunction of equipments. Pepper (*Capsicum frutescens* L.), a major arable crop in Nigeria and many African countries, was chosen for this study because it has become increasingly popular and most farmers have adopted to the cultivation of the plant. This study aims to evaluate the effects of crude oil pollution on the growth performance of *Capsicum* (pepper).

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria(long. 7°38'N and lat. 11°11'E). Topsoil (0-15 cm), obtained from Oredo Flow Station field of the Nigerian Petroleum Development Corporation (NPDC), Ologbo, Benin City was properly mixed, put into polythene bags to a weight of 15kg. This was watered and allowed to settle. The *Capsicum* seeds were obtained from the Agricultural Development Project, Benin City, Edo State, Nigeria. The viable seeds were determined by the chemical viability test. The seeds were nursed for three weeks, thereafter seedlings of relatively age were transplanted into the various concentration of crude oil polluted soil.

The experiment was laid out in a completely randomized block design. There were three treatments of crude oil polluted soil consisting of control (C), medium impacted soil (MI) and heavily impacted soil (HI). Each treatments consists of three replications. Soil samples were taken (0-15cm depth) at the sampling site just before loading of the polythene bags. The growth parameters were measured at one week interval after transplanting. These includes; plant height, leaf area, leaf number, fresh and dry weight matter, chlorophyll content and yield. The plant height was obtained by measuring the plant from the soil level to the tip 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 [6]. 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 weight using the method of Ekpo and Ebeagwu (2009) to get the dry weight matter [7]. Chlorophyll determination was done using the method of Arnon (1949) [8]. This was done for both the dry and rainy season. The data were analyzed using the analysis of variance (ANOVA) technique while LSD was used to separate their means.

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. Plant height was more or less constant initially after transplanting until at 2-4WAT. Significant difference ($P< 0.05$) was observed inthegradual increase of plant height in MI soils while those in the HI soils has stopped increasing in height at 3-6WAT until plant eventually dried up (Table 1 and 2) in both seasons. It was observed that there were significant differences in the leaf number. Crude oil pollution at 3WAT and 6WAT in all concentrations resulted in a significant reduction in leaf number when compared with the control ($p<0.05$). At 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 at both seasons (Table 5 and 6). The values obtained shows insignificant difference ($P>0.05$) in crude oil polluted soils as compared with control (Table 7 and 8) in both rainy and dry season. Although, at3-4WATthere was significant reduction ($p<0.05$) in the chlorophyll content present in the crude oil polluted soil as compared to the control (Table 7).

Table 1.Mean plant height during the rainy season.
Values are means of 3 replicates ±S.E

Crude oil Concentration		Plant height (cm) Weeks after Transplanting (WAT)					
		1	2	3	4	5	6
C	**F**	7.47±0.81 [ab]	8.68±0.92 [ab]	11.58±0.61 [a]	17.10±0.86 [a]	22.82±1.21 [a]	26.25±1.00 [a]
M	**F**	6.18±0.55 [c]	6.73±0.60 [c]	7.13±0.54 [bc]	7.17±0.51 [c]	6.85±0.57 [c]	6.03±0.44 [bc]
H	**F**	6.53±0.48 [b]	6.87±0. [36bc]	6.87±0.32 [cd]	7.37±0.40 [c]	6.38±0.34 [c]	5.85±0.41 [c]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 2.Mean plant height during the dry season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Plant height (cm) Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	6.35±0.33 [a]	7.92±0.27 [a]	10.08±o.46 [a]	14.68±0.72 [a]	14.90±0.98 [a]	14.38±0.62 [a]
M F	5.97±0.23 [a]	6.25±0.28 [a]	6.42±0.34 [b]	6.62±0.25 [c]	6.62±0.25 [c]	6.62±0.25 [b]
H F	6.67±0.80 [a]	6.75±0.67 [a]	6.90±0.75 [b]	6.72±0.36 [c]	6.72±0.36 [c]	6.35±0.62 [bc]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 3.Mean Leaf number of *C. frutescens* during the rainy season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Leaf numberWeeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	1.89±0.26 [b]	6.67±0.49 [a]	8.83±0.75 [a]	16.5±1.65 [a]	22.83±2.47 [a]	26.33±2.08 [a]
M F	1.84±0.23 [b]	5.67±0.33 [b]	4.17±0.31 [b]	3.83±0.31 [c]	3.00±0.45 [bc]	2.50±0.34 [b]
H F	1.82±0.18 [b]	4.67±0.42 [c]	3.67±0.21 [bc]	3.17±0.17 [cd]	2.33±0.21 [c]	1.83±0.40 [c]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 4.Mean Leaf number ofduring the dry season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Leaf numberWeeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	3.67±0.33 [b]	5.33±0.42 [a]	7.17±0.31 [a]	9.67±0.88 [a]	18.00±2.27 [a]	24.25±3.12 [a]
M F	4.50±1.44 [ab]	3.00±0.26 [c]	2.73±0,23 [b]	2.50±0.43 [c]	2.50±0.43 [c]	2.50±0.43 [bc]
H F	4.00±0.26 [b]	3.50±0.22 [c]	3.17±0.31 [b]	2.50±0.22 [c]	2.00±0.91 [c]	0.00±0.00 [d]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 5.Mean Leaf Area during the rainy season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Leaf Area (cm^2) Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	1.89±0.26 [a]	2.32±0.25 [a]	3.02±0.53 [a]	8.10±0.76 [a]	9.54±0.78 [a]	11.95±1.15 [a]
M F	1.84±0.23 [a]	1.93±0.29 [a]	1.85±0.33 [b]	1.85±0.33 [b]	1.19±0.27 [b]	0.74±0.09 [bc]
H F	1.82±0.18 [a]	1.92±0.22 [a]	1.89±0.22 [b]	1.49±0.15 [b]	0.73±0.29 [c]	0.28±0.09 [cd]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 6.Mean Leaf Area during the dry season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Leaf Area (cm^2) Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	0.89±0.07 [a]	1.31±0.15 [a]	1.91±0.16 [a]	2.75±0.73 [a]	4.27±1.26 [a]	4.54±0.74 [a]
M F	0.54±0.07 [a]	0.64±0.11 [b]	0.65±0.09 [b]	0.69±0.07 [c]	0.69±0.07 [b]	1.23±0.47 [b]
H F	0.84±0.10 [a]	1.05±0.09 [ab]	1.03±0.09 [b]	0.70±0.11 [c]	0.73±0.24 [b]	0.00±0.00 [d]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 7.Mean Chlorophyll content during the rainy season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	0.04±0.03 [a]	0.06±0.04 [a]	0.09±0.03 [a]	0.09±0.05 [a]	0.04±0.02 [a]	0.06±0.04 [a]
M F	0.05±0.02 [a]	0.05±0.03 [a]	0.03±0.01 [b]	0.04±0.03 [b]	0.004±0.01 [b]	0.011±0.03 [b]
H F	0.04±0.03 [a]	0.03±0.01 [b]	0.03±0.02 [b]	0.01±0.01 [c]	0.004±0.01 [b]	0.009±0.01 [bc]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

Table 8.Mean Chlorophyll content during the dry season.
Values are means of 3 replicates ±S.E

Crude oil Concentration	Weeks after Transplanting (WAT)					
	1	2	3	4	5	6
C F	0.05±0.03[a]	0.047±0.04[a]	0.004±0.03[b]	0.024±0.05[a]	0.022±0.02[b]	0.04±0.04[a]
M F	0.04±0.02[a]	0.013±0.03[b]	0.006±0.01[a]	0.002±0.03[c]	0.04±0.01[a]	0.02±0.03[b]
H F	0.05±0.03[a]	0.012±0.01[b]	0.006±0.02[a]	0.014±0.01[b]	0.04±0.01[a]	0.02±0.01[b]

**Means in the same column with same letter(s) are not significantly different (P≥0.05), CF = C. frutescens in Control, MF = C. frutescens in Medium polluted soil, HF = C. frutescens in Heavily polluted soil, WAT = Weeks after transplanting*

DISCUSSION

The present study demonstrated the differential effect of crude oil of the growth performance of *Capsicum frutescens.* There waslittle variation in plant height between treatments and control at 1-2WAT and a significant difference 4-6WAT.However, plant growth in the crude oil polluted soil for MI and HI soil were slowest 3-6WAT(Table 1 and 2). This may be due to increased phytotoxicity of the crude oil to the plants. Heavy metals present in the crude oil can accumulate in plants and affect metabolic processes [9]. The plant death 4WAT in crude oil polluted soil was recorded in treatments at both seasons. 100% mortality was recorded in HA and HF and 65% mortality in MA and MF (Table 5 and 6). This finding is in agreement with the previous work by Pezeshi *et al.* (1995) when *Spartinaalterniflora*was oiled with Bunker C oil [10]. The treatment resulted in complete plant mortality and no apparent recovery. The study showed that there was a significant difference in growth between crude oil treated plants and plants used as control. Also, Gill *et al*. (1992) observed a positive relationship between degree of growth retardation and concentration in crude oil contaminated soil [11] while Odjegba and Sadiq (2002) noticed a significant reduction in heights of seedlings for all levels of treatment relative to the control [12]. The low seedling emergence and plant height in this study may have been due to the use of unweathered bonny light crude oil, classified as a class A crude oil which is highly toxic to biota, fish and man. It contains the lighter, more volatile and most phytotoxic components of crude oil [13].

Some leaves in the polluted soils experienced chlorosis, necrosis, and withering of leaves were observed in soils with MI and HI soils at 3WAT. Some of these symptoms such as stunted growth and chlorosis have been attributed to Zn toxicity [14]. This observation agrees withOpeolu (2000) who reported that light oil pollution caused yellowing of leaves and dropping of leaves soon after planting while heavy oil contamination resulted in complete shedding of leaves [15]. 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. Significant decreases in leaf area were recorded in both MI and HI crude oil polluted soil at both seasons with the lowest value obtain in HF at 6WAT. The uptake of toxic substances like heavy metals initially by the roots is finally received by the mesophyll cells of the leaves [16]. This may cause reduction in leaf growth and development. The physical properties of crude oilimpose some stressful conditions, which interferes with water uptake and gaseous exchange [17].The analysis of leaf chlorophyll did not show any specific pattern, as chlorophyll values of *Capsicum* plant grown in soils treated with crude oil were insignificantly different from those in the controls during the dry season (Table 7) as compared to the rainy season (Table 8). This is at variance with the study of Odjegba and Sadiq (2002), who observed that chlorophyll levels in the fresh leaves of plants grown in spent engine oil-treated soils was lower than those of the control [12]. Oil pollution of soil leads to build up of essential (organic C, P, Ca, Mg) and non-essential (Mg, Pb, Zn, Fe, Co, Cu) elements in soil and the eventual translocation in plant tissues [18]. Soils polluted with crude oil result in the soil remaining unsuitable for crop growth and depending on the degree of contamination, type of soil and soil environment, the soil may remain unsuitable for crop growth for months or years until the oil is degraded to tolerable levels [19].

CONCLUSION

The present study shows that crude oil adversely affect the growth performance of *Capsicum frutescens* and the soil fertility. *Capsicum* plants that survived in contaminated soils became stunted and chlorotic. Crude oil pollution has been found to have economic implications on growth and yield of agricultural crops. In order to reduce the high risk ofoil pollution in our environment there is need to create more awareness on the harvoc of oil spillage on the agricultural sector of the economy.

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