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Effect of Mild Steel Buried in Crude Oil polluted Soils on the Growth response of two maize (*Zea Mays L.*) Varieties

[1]Onwugbuta,G. C.and[2]Orji, O. A.
[1]*Department of Biochemistry/ Chemistry Technology, School of ScienceLaboratory Technology, University of Port Harcourt, Port Harcourt*
[2]*Department of Crop/Soil Science, Rivers State University, Nkpolu, Port Harcourt*
Corresponding Author:Orji, O.A.

Abstract: *This study reveals the effect of 300g of mild steel buried in different levels of crude oil(0, 40, 80, 120 and 160ml) polluted soils (3kg) on the growth response of two maize (ZeaMays L.) varieties. The plant height, leaf length, and leaf number were measured. There was a gradual increase in the growth parameters with age in soils with low levels (0, and 40ml) of treatment. The higher the treatment levels, the higher the corrosion of mild steel, and the higher the iron content in the soil. There was higher chlorosis and reduction in leaf size in the 160ml crude oil treatment in the white maize compared with the yellow maize. This could be as a result of the penetration of oil into the plant tissues and highly corroded and dissolved iron in the soil matrix. It was therefore, concluded that crude oil/ iron stress affected the growth of the maize plant varieties. However, the yellow maize variety showed higher degree of tolerance than the white maize variety in the three soils studied.It was also established that soils of the Coastal Plain Sands had higher resistance to metal corrosion and dissolution than those of the Sombriero Warri and Meander Belt Deposits.*

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I. Introduction

When pipes corrode, oil blow-outs and pipeline leakages occur. These corroded iron/oil leakages have disastrous consequences on land, freshwater swamps and coastlines (Nduuku, 2015). Pipeline leakages have adverse effects on crops, plants and soil. Growth of vegetation on contaminated areas may be prevented, retarded, or accelerated depending on changes taking place in soil properties (Osuji, 2001).Changes in metabolic processes like photosynthesis, mineral uptake and respiration may lead to growth inhibition and plant death. According to Adam and Duncan (2002) the increasing aromatic content of the crude oil confers toxicity on it hence it is herbicidal.

Excess iron/oil penetration into a plant will cause disruption in the plant`s physiological processes by interfering with metabolic processes such as food and mineral uptake, respiration, photosynthesis also is impaired, resulting in chlorosis of leaves and sometimes wilting of the entire plant (Ekundayo et al. 2001, Achuba, 2006). Because of the changes in soil properties as a result of oil spill and waste deposition, and their effects on plant growth, the problem of the quality of pipes (iron) to be laid becomes a great challenge to the agronomists in other to reduce corrosion rate and avoid oil leakages and high iron accumulation in soils. However, Iron involves in the synthesis of chlorophyll, and it is essential for the maintenance of chloroplast structure and function. Excess iron in plant cell is toxic. Iron reactivity with reduced forms of oxygen produces radical elements that can cause a loss of integrity and kill the cell.Iron is translocated from roots to shoots as a ferric-citrate chelate form, and this is transported to actively growing short regions (Kobayashi and Nishizawa 2007).This research is therefore, aimed at determining the impact of corroded mild steel (iron) in crude oil polluted soils on the growth response of two maize varieties.

II. Materials and Methods

Three contrasting soil types from three geologic zones were sampled comprisingCPS – Odagwa, Etche Local Government Area, Rivers State; SWD – Ahoada, Ahoada Local Government Area, Rivers State, andMBD – Kaiama, Yenagoa Local Government Area, Bayelsa State. The experiment was conducted in complete randomized design (CRD) with three replications for both polluted and control soils. 3.0kg of surface soils was collected and bagged inside each experimental pot. Mild steel coupons were crushed using a milling machine, and 300g of it was weighed and buried inside each of the test pots. The soils were then treated with un-weathered crude oil levels of 0.00, 40.0, 80.0, 120.0 and 160.0ml(Sp. Gravity 0.8689g/cm) respectivelyand left under natural condition for six months prior to planting. Four maize seeds comprising of yellow and white maize varieties which are the early maturing varieties were planted respectively in March, 2017 to approximately 2cm deep in each of the pots six months after crude oil contamination. The planting pots were perforated at the sides and bottom two weeks before planting to allow for aeration and drainage of excess water (Ayotamuno and Kogbara, 2007). The four maize seeds originally germinated in the pots were later thinned to two stands two weeks after germination (2 WAG).The surface soils were collected two weeks before planting and two weeks after harvest and were analyzed for some physico- chemical properties such as; soil texture, pH, organic matter, total nitrogen, iron content and others using the standard methods for soil and plant analysis (AOAC, 2005; Eno et al. 2009).Growth parameters were also measured as outlined byAyotamuno and Kogbara(2007).Plant Height was measured from the soil level to the terminal bud using a meter rule. The leaf with the longest length was also measured with a meter rule while the leaf number was measured by counting the number of leaves that were still attached to the petiole of the plant. All the measurements were made every 2weekstill 12weeks after planting. The experiment lasted for 12 weeks.

Analysis of Data

The results of the growth parameters were subjected to statistical analysis using graphical method and ANOVA to determine the level of significance at 1% confidence limit.

III. Results and Discussion

The results showed some variations in the physico-chemical properties (Tables 1-2). The particle size distribution showed that percent sand increased as pollution increased, with seepage areas polluted with 160ml crude oil recording the highest (80.5%), (85.7%), and (5.0%) and the controls with the least (79.0%), (83.5%) and (3.8%) for Odagwa, Ahoada, and Kaiama soils respectively.Moisture contents were equally high ranging between 10.23% (Odagwa control) to 33.04% inKaiama soils polluted with 160.0ml of crude oil, respectively. The acidity of the soils increased with increase in crude oil pollution. Hence, the highest pH value was found at Ahoada control site and the lowest value found at Kaiama soils polluted with 160.0ml of crude oil. The reverse is the case for the samples collected after harvest for all the parameters, as shown in Table 2 below.THC, Fe, Al, Mn, and OM increased as pollution increases, with decrease in the control soilswhileTN decreased as pollution increases.

Table 1 Selected Physico-Chemical Properties of Crude Oil/Iron Polluted Surface Soils (0-30cm) Sampled Two Weeks before Planting

Parameter/Unit	**Locations**								
	Odagwa(CPS)			**Ahoada(SWD)**			**Kaiama(MBD)**		
Treatment (ml)	Control (0)	40	160	Control (0)	40	160	Control (0)	40	160
THC (mg/kg)	12.62	26.83	40.52	23.04	60.07	74.42	62.10	115.62	142.84
Al(ppm)	1.18	1.20	1.27	1.21	1.48	1.52	3.75	4.94	5.63
Fe (ppm)	1.07	1.10	1.30	3.75	3.92	4.08	4.45	4.50	6.50
M_n^+(cmol/kg)	0.02	0.07	0.12	0.06	0.08	0.26	1.19	2.26	4.80
TN (%)	0.31	0.28	0.22	0.33	0.26	0.23	0.44	0.36	0.34
OM (%)	1.72	2.04	2.46	1.80	2.07	2.39	2.05	2.95	3.44
pH	5.61	5.26	5.22	5.90	5.81	5.64	4.24	4.15	4.10
Sand (%)	79.0	80.0	80.5	83.5	85.0	85.7	3.8	4.0	5.0
Silt (%)	9.0	9.0	9.0	10.5	10.0	9.3	29.2	29.2	28.7
Clay (%)	12.0	11.5	10.5	6.0	5.0	5.0	67.0	66.8	66.3
Textural class	SL	SL	SL	LS	LS	LS	C	C	C

Table 2 Selected Physico-Chemical Properties of Crude Oil/Iron Polluted Surface Soils (0- 30cm) Sampled two Weeks after Harvest

Parameters/ Unit	**Locations**								
	Odagwa(CPS)			**Ahoada(SWD)**			**Kaiama(MBD)**		
Treatment (ml)	Control (0)	40	160	Control (0)	40	160	Control (0)	40	160
THC (mg/kg)	12.62	18.15	26.00	23.04	48.30	52.00	62.10	107.08	120.55
Al(ppm)	1.18	1.12	1.18	1.21	1.29	1.36	3.75	3.72	4.02
Fe (ppm)	1.07	0.98	1.16	3.75	2.70	3.02	4.45	4.01	4.71
Mn^+(cmol/kg)	0.02	0.03	0.02	0.06	0.05	0.05	1.19	2.17	3.02
OM (%)	1.72	1.86	1.90	1.80	1.93	2.00	2.05	1.95	2.87
TN (%)	0.24	0.22	0.16	0.27	0.25	0.20	0.35	0.33	0.28

pH	5.61	5.96	5.98	5.90	5.82	5.86	4.24	4.68	4.71
Sand (%)	78.0	79.0	79.0	83.5	84.8	85.8	3.8	4.0	5.0
Silt (%)	9.0	9.0	9.0	10.0	10.4	9.4	29.2	29.0	27.0
Clay (%)	13.0	12.0	12.0	6.5	4.8	4.8	67.0	67.0	68.0
Textural class	SL	SL	SL	LS	LS	LS	C	C	C

Growth Response of Zea mays L. in Different Soil Types

The growth response of the effects of mild steel buried in crude oil contaminated soils on maize varieties are shown on Figures 1-3, respectively using two-way analysis of variance and graphical representation. The mean and standard deviation of the growth parameters were used to discuss the results.The peak mean value of 5.09±1.06cm of the number of leaves of maize was obtained from the yellow maize plants grown in 40.0ml crude oil polluted soils of the meander belt deposits (Kaiama), and the lowest mean value of 2.74±1.40cm was found from the white maize variety in Odagwa (CPS) when the soils were polluted with160.0ml crude oil 12WAP, as illustrated in Tables 3a-c and Figs.1a-c respectively.

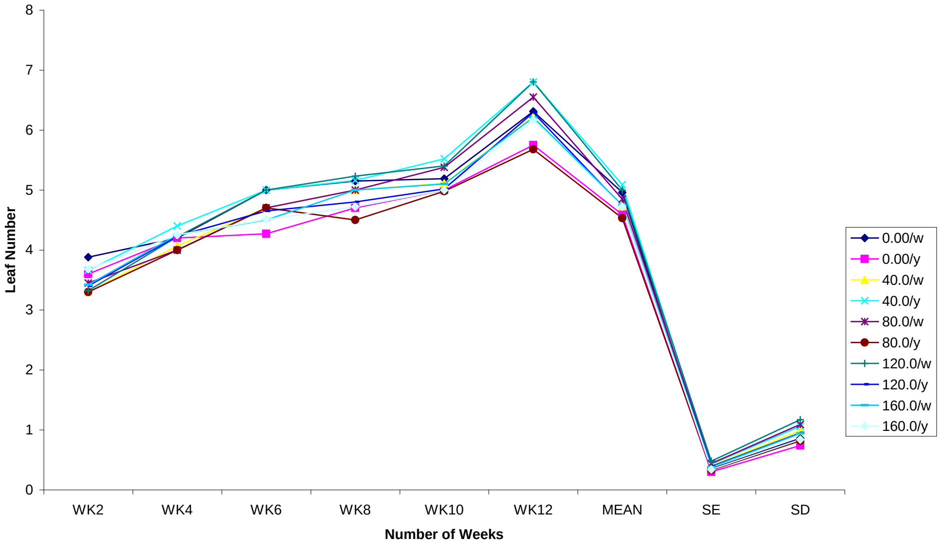

Fig 1a: Graph showing variation of leaf number of two maize (*zea mays L.*) varieties(white and yellow maize) in crude oil/ iron contaminated soil 12WAP in Kaiama- MBD (C)

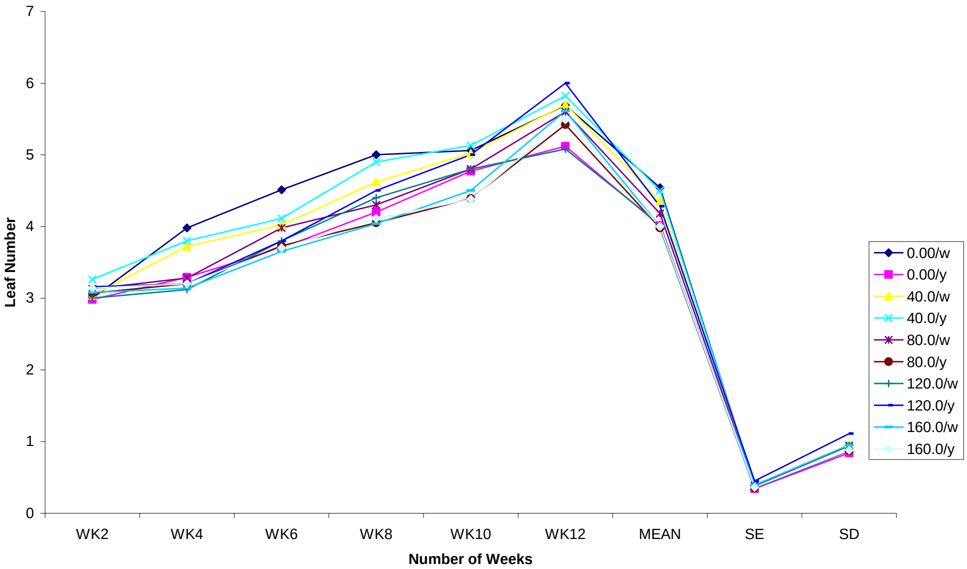

Fig 1b: Graph showing variation of leaf number of two maize (*zea mays L.*) varieties(white and yellow maize) in crude oil/ iron contaminated soils 2 – 12WAP in Ahoada- SWD (SL)

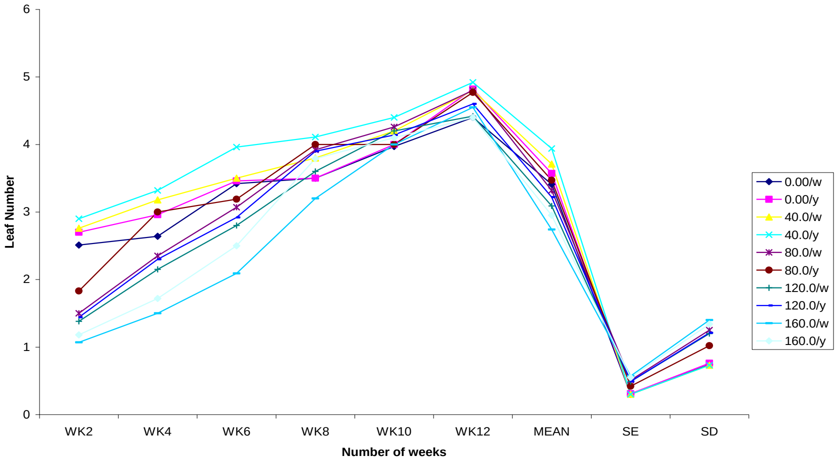

Fig 1c: Graph showing variation of leaf number of two maize (*zea mays L.*) varieties (white and yellow maize) in crude oil/ iron contaminated soils 2 – 12WAP in Odagwa- CPS (SL)

The highest mean leaf lengths of 27.1±7.9cm were observed in 40.0ml/ iron polluted Kaiama soils (MBD) from the yellow maize variety, with the lowest mean of 6.50±2.4cm found in the coastal plain sands of Odagwa for the white variety of maize grown in 120.0ml crude oil polluted soil 12WAP, respectively (Figs. 2a-c).

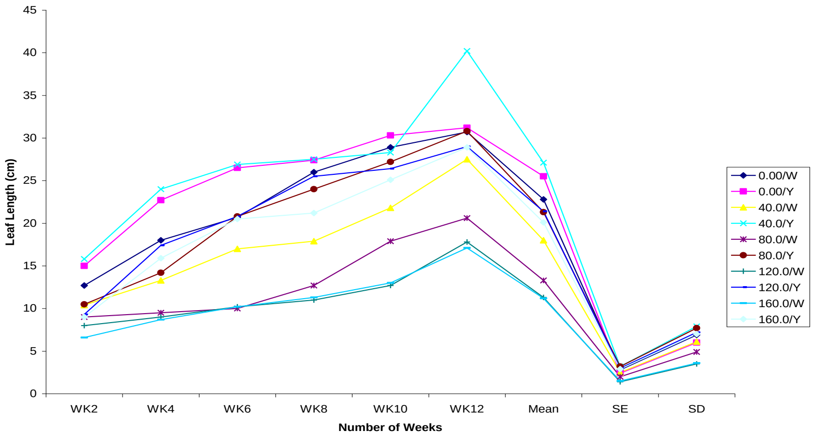

Fig 2a: Graph showing variation of leaf length(cm) of white and yellow maize varieties in crude oil/ iron contaminated soils 2 – 12WAP in Kaiama- MBD (C)

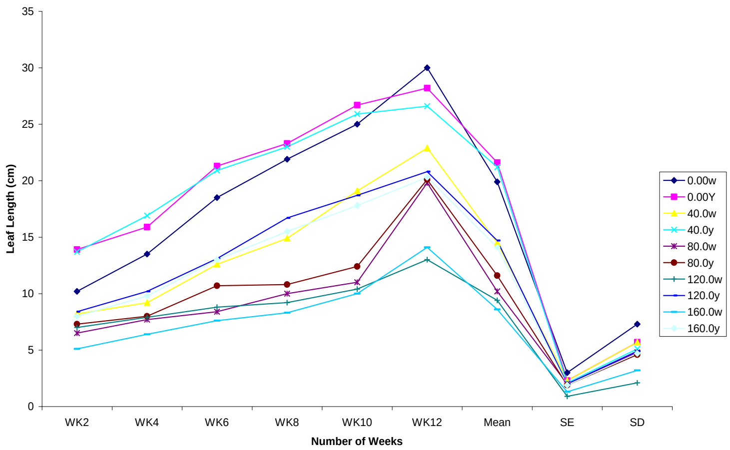

Fig 2b: Graph showing variation of leaf length(cm) of white and yellow maize varieties in crude oil/ iron contaminated soils 2 – 12WAP in Ahoada - SWD (SL)

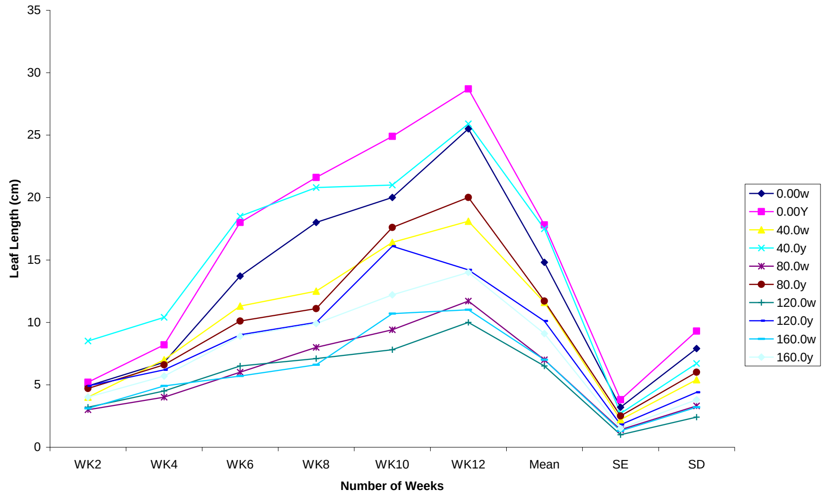

Fig 2c: Graph showing variation of leaf length(cm) of white and yellow maize varietiesin crude oil/ iron contaminated soils 2 – 12WAP in Odagwa- CPS (SL)

The highest mean value (30.3+ 6.30cm) of plants height were obtained at the meander belt deposits of Kaiama from the yellow maize plants grown in 40.0ml crude oil contaminated soils, while the white maize plants grown in 160.0ml crude oil contaminated soils at Odagwa (CPS) gave the least mean value of plants heights of 9.7+3.40cm at 12WAP, as illustrated in Figs. 3a-c, respectively.

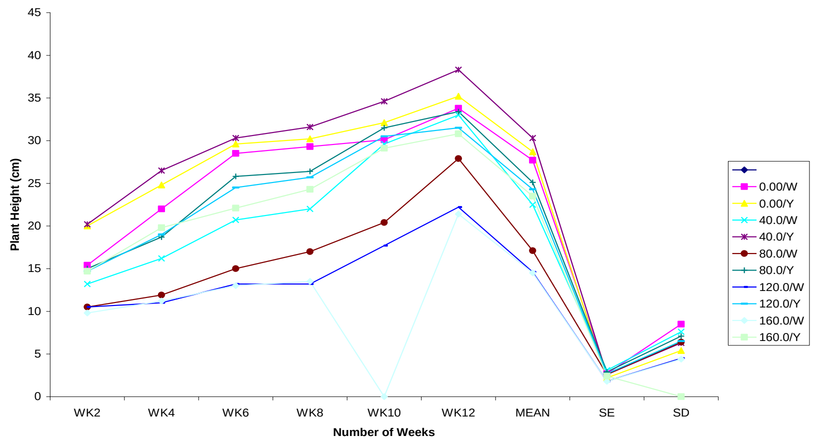

Fig 3a: Graph showing variation of plant height (cm) of white and yellow maize varietiesin crude oil/ iron contaminated soils 2 – 12WAP in Kaiama – MBD (C)

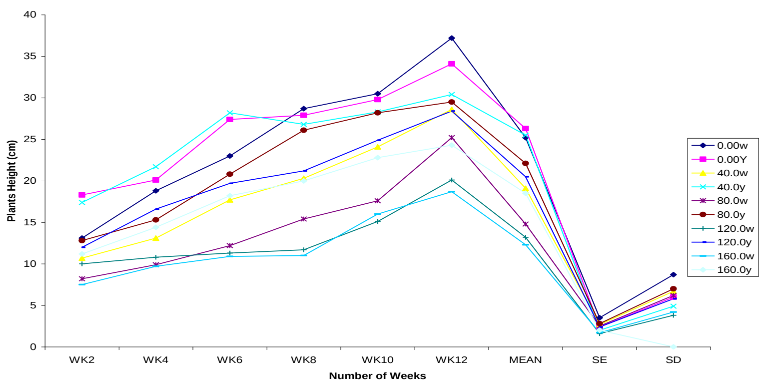

Fig 20(b) Graph showing Variation of Plant Height (cm) of white and yellow maize varieties in crude oil contaminated soils 2 – 12 WAP in Ahoada-SWD (LS)

Fig 3b: Graph showing variation of plant height (cm) of white and yellow maize varietiesin crude oil/ iron contaminated soils 2 – 12WAP in Ahoada - SWD (LS)

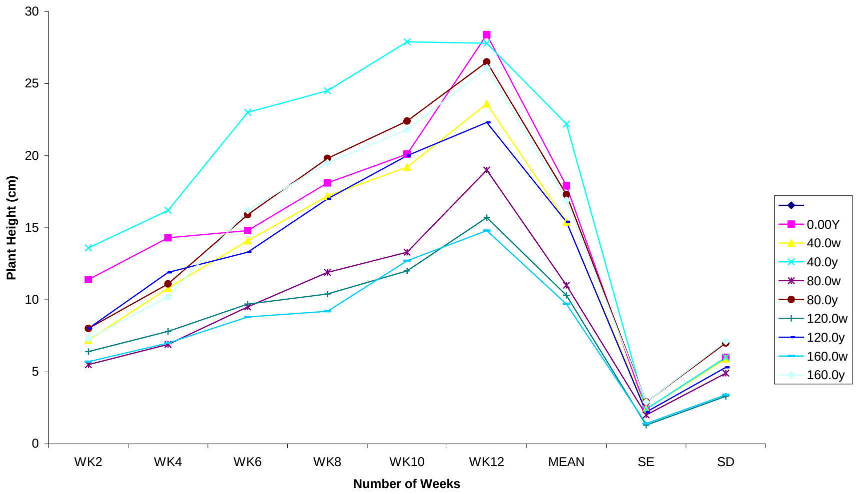

Fig 3c: Graph showing variation of plant height (cm) of white and yellow maize varieties in crude oil/ iron contaminated soils 2 – 12WAP in Odagwa –CPS (SL)

There was gradual increase in all measured growth parameters with age. The highest mean values were obtained for the yellow maize plants grown in 40ml crude oil/ iron treated soils in all growth parameters measured except leaf number. This is in agreement with Ogboghodoet al.(2004) and Odjuvwuederhie et al.(2006), respectively. The above results also indicate that high level of corroded iron/ crude oil contaminated soil reduces growth parameters in both varieties, thus plant height, leaf length, and the number of leaves of the maize varieties are reduced. Ekundayo et al., 2001 in his report revealed that increasing dose of crude oil to the soil leads to impaired water drainage and oxygen diffusion, which in turn, leads to delayed seed germination. This was observed in this study when the level of crude oil/ iron in soils was increased up to 160.0ml. The infiltration of the contaminant into the soil pores leads to the expulsion of air thus depleting oxygen reserves in the soil and impeding its diffusion to the deeper layers (Ayotamuno et al; 2006). Thereafter, as microbial activities (involving the utilization of oxygen for biodegradation of the contaminant) increase, available oxygen diminishes in the soil environment. This limits the survival of plants as they then lack essential elements for their growth. Odjuvwuederhie et al. (2006) had earlier reported that crude oil stimulated growth in most crops.Ayotamuno and Kogbara (2007) reported that enhancement of growth may be related to the ability of the plants to metabolize hydrocarbons. The observed leaf chlorosis in 120 to 160ml treatment in the yellow maize and 80 to 160ml in the white maize from 4 to 8 WAP was probably due to the penetration of the oil into the plants tissues. These findings correspond with the reports of Nwilo and Badojo (2005) that oil applied to roots can move up to the leaves and oil applied to the leaves can move down into roots. The observed yellowing of leaves resulted in loss of photosynthetic ability and general physiological weakening of the plants. Stunted growth, wilting and withering may all be attributed to one or a combination of these stress conditions (Ayotamuno and Kogbara, 2007). Statistically, a two-way analysis of variance used indicates that there was a significant difference between number of leaves, leaf length, and stem height of the Zea mays varieties. Similarly, the relationships between the growth parameters studied and the three soil types are all significant at $p < 0.05$.

IV. Conclusion

There was growth retardation; reduction in leaf size, deepening of green leaf color (particularly in the youngest leaves); wilting of shoots (in Kaiama); yellowing and dieback of oldest leaves (especially from the tips and margins); reddening or purpling of stems and older leaves; and formation of precipitates on roots, in agreement with Hemalatha and Venkatesan, 2011, especially in soils containing 160.0ml crude oil and mainly in the Meander Belt Deposits. These conditions generally imply low soil fertility, which in turn implies low agricultural productivity. It can be concluded that crude oil/ iron stress affected the physiological processes of the maize plants, leading to low metabolite formation. However, the yellow maize variety showed higher degree of tolerance than the white maize.

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