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Effect of Crude Oil Pollution of Soil and Amelioration Treatment on the Growth of Eight Varieties of *Manihot Esculenta* Crantz.

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ABSTRACT

The effect of crude oil pollution of soil and amelioration treatment on the growth parameters of eight varieties of *Manihot esculenta* stem were carried out in the field using perforated polythene bags. The soil samples were polluted with four different levels of crude oil (0%, 2%,4% and 6%) and amended with organic supplement (goat and chicken droppings at a ratio of 1:1) at four rates of application (0, 10, 20, and 30 grammes) respectively and 0% served as control. Heavy metals were extracted from the improved varieties. The mean results obtained after sixteen weeks showed that plant height, leaf area, petiole length, internode length and crop yield decreased with increase in crude oil concentrations in the following varieties TMS/79/4779, TME/419, TMS/98/0057, NR8082 and TMS/92/0323. In 2% concentration of crude oil, growth was stimulated above the control and better yield in TMS/30572, TMS/97/0505 and TMS/96/0581 varieties. The quantity of trace elements such as Zn, Ni and Cr was increased while the quantity of Cd, Fe and Pb was reduced. This study recommended that varieties TMS/30572, TMS/97/0505 and TMS/96/0581 can be planted on the site polluted with crude oil and amended with organic supplements.

Keywords: *Manihot esculenta,* amelioration, soil crude oil pollution.

INTRODUCTION

Manihot esculenta (cassava) is the fourth most important food crop in the tropics. It is a perennial woody shrub, grown as an annual; it belongs to the family Euphorbiaceae and the genus *Manihot* which includes 97 other species [5]. Cassava is cosmopolitan in distribution and is found in practically all habitats in West Africa. The plant grows to about 609.6cm tall in frostfree regions [12].

Cassava produces a high yield of tuberous roots in six months to three years after planting. Cassava is a drought tolerant crop rarely irrigated, but it does produce better tubers when it receive regular watering and the soil is not allowed to completely dry-out [11].

Manihot esculenta is an evergreen tree or shrub with palmately simple leaves which resemble castor bean (*Ricinus communis*) and has 5-9 lobes depending on the type of variety. The leaves are alternately arranged with reticulate venation. The apex is cuspidate with entire margin and has a glabrous texture, spearhead lanceolate in shape, 10-17cm long and 2.5-6.0cm in diametre [7, 8]. Cassava has some economic importance, which includes edible, industrial, medicinal and traditional uses, etc. [10].

Crude oil is a complex mixture of chemicals, which vary widely in composition, though it is rich in hydrocarbons (aliphatic and aromatic compounds). Whenever there is oil pollution, there is destruction of biodiversity, loss of soil fertility, degradation of farmland and damages to ecosystem [2,14]. Oil spillage on soil inhibits plant growth [6].

Oil spills is rampant in Niger Delta regions where these plants are grown, there is a need therefore to screen the crude oil resistant varieties in order to advise our farmers. Hence this experiment is aimed to study the effect of crude oil pollution of soil on growth parameters of cassava.

MATERIALS AND METHODS

Collection and identification of plant materials, soil type and organic supplements:

Eight varieties of cassava cuttings were collected from Akwa Ibom Agricultural Development Programme (AKADEP), Oron Zone and viable cuttings were used for this research. Sandy loamy soil samples were collected from Botanical garden, University of Uyo, Uyo. The organic supplements used were obtained from local farmers in Akwa Ibom State, crude oil was obtained from Exxon Mobil Nigeria Unlimited, Eket, Akwa Ibom State. The materials used were identified by Professor G. J. Esenowo, Department of Botany and Ecological Studies, University of Uyo, Uyo.

Study area

This research was carried-out in Uyo the capital city of Akwa Ibom State, Nigeria. Uyo is a city in South-South Nigeria found between latitude 5.023209^{0}N and longitude 7.9238892^{0}E, it has an average temperature of 25.1-

27.8^{0}C and an annual rainfall range of 33-37.8mm and it has land area of 115km^2 and a population of 1,400 million persons/km^2.

Soil analysis
The physiochemical properties of the experimental soil were analysed using standard procedures as proposed by AOAC [4]. The pH values were measured with electro-pH meter, organic carbon was determined by dictro-meter oxidation method of Walkey-Black. Potassium and sodium were determined by the EDTA filtration method. The particle size was determined by the hydrometer method according to AOAC [4, 23].

Pollution of soil samples
Four kilogrammes (4kg) of sterilised loamy soil were weighed using a Mettler (P-165) weighing balance into perforated polythene bags of 38cm in width and 40cm in length to enhance drainage. Each soil sample was thoroughly mixed with 2%, 4% and 6% of crude oil and incubated for three days according to the methods of Udo and Oputa [22]. The unpolluted soil sample served as a control for each treatment according to the methods of Amadi *et al.* [3]; Umoh and Esenowo [24].

Bioremediation treatment
Organic supplements made up of goat and chicken droppings at the ratio of 1:1 were added to the polluted soils (2%, 4% and 6%, at the rate of 10, 20 and 30 grammes respectively according to the methods of Ubom and Essien [20]. The mixture of crude oil, loamy soil and organic supplements were left undisturbed for three days to facilitate loosening of the oil constituents [3, 21].

Pre-germination studies
Eighteen centimetres of cassava cuttings were sown directly into the polythene bags, two cuttings were sown in each bag. These experiments were maintained under daylight condition and they were watered as need arose. The seedlings were allowed to grow for four months to determine their growth performance.

Determination of growth parameters
The growth parameters such as plant height, leaf area, internode length and petiole length were measured using metre rule in centimetres. The roots lengths were determined after harvesting. The primary and secondary roots (tubers) were measured with metre rule at the period of sixteen weeks.

Leaf area determination
Leaf area was measured according to the methods of Umoh and Esenowo [24]. The leaf area of each seedling was determined by multiplying the leaf length by the leaf width and correlation co-efficient (r) according to the methods of Hoyt and Brafort [13].

$$LA = L \times W \times r$$

Where,
LA = Leaf area
L = Leaf length
W = Leaf width
r = Correlation co-efficient

Determination of correlation co-efficient (r)
The correlation co-efficient (r) of cassava leaves was calculated according to the methods of Hoyt and Brafort [13].

Determination of heavy metals
Heavy metals such as Zn, Fe, Pb, Ni, Cr and Cd were determined using A. A. spectrophotometer.

Statistical analysis
The data obtained were subjected to two-way analysis of variance (ANOVA) using the methods of Sokal and Rohf [19] to determine the level of significance.

RESULTS AND DISCUSSION
The physiochemical properties of the experimental soil were rich in available phosphorus, ECEC, EC and pH while organic matter, silt, clay, Na, Ca, Mg, organic carbon and K were relatively low in unpolluted soil (Table-1).

The results obtained revealed that the leaf area of TMS/30572, TMS /97/0505 and TMS/96/0581 showed stimulation above the control at 2% concentration while varieties TMS/98/0323, TMS/97/4779, TME/419, TMS/98/0057 and NR8082 were significantly ($p<0.05$) reduced at the same concentration (Tables-2A-H). In varieties TMS/30572, TMS/96/0581 and TMS/97/0505, significant ($p>0.05$) growth increase occurred in petiole length, internode length, plant height and yield (Tables 2 E, F, and H). TMS/30572, TMS/97/0505 and TMS/96/0581 were able to produce root tubers while TMS /92/0323 and NR8082 did not produce root tubers (Table-3). Based on their growth performance, these varieties - TMS/30572, TMS/96/0581 and TMS/97/0505 are suitable for planting in the areas where there is oil spill with amelioration treatment.

In TMS/30572, at 2% and 4% concentrations there was slight reduction in Zn, Fe and Pb while at 6% concentration Zn, Fe, Ni and Cr showed a slight increase above the control. In TMS/97/0505, at 2% and 4% concentrations Fe and Pb showed slight reduction while the rest showed a slight increase. Similarly, in TMS/98/0581 there was a slight increase in Zn and Pb while Fe, Ni, Cr and Cd had a slight reduction (Table-4).

Table-1: Physiological properties of experimental soil

S.No.	Parameters	Unpolluted soil	Polluted soil
1.	pH	6.51	6.00
2.	Organic matter (%)	1.98	4.86
3.	Total nitrogen (%)	0.06	0.24
4.	Available P. (mg/kg.)	39.99	67.00
5.	Ex. Ca. (cmol./kg.)	3.25	5.52
6.	Ex. N. (cmol./kg.)	0.06	0.08
7.	Ex. K. (cmol./kg.)	0.09	0.25
8.	Exchange acidity	2.62	2.60
9.	ECEC. (cmol./kg.)	7.32	10.43
10.	Bases saturation (%)	64.81	75.07
11.	Silt (%)	4.00	6.00
12.	Clay (%)	4.20	8.00
13.	Exchange Mg. (cmol./kg.)	1.30	2.00
14.	Organic carbon	1.61	3.09
15.	C/N ratio	91.67	12.89
16.	Particle sizes sand (%)	91.80	86.00
17.	EC. (gs/m)	0.068	0.0567

Key:
Ex-exchange
ECEC-effective cation exchange capacity

Table-2: Mean (± sd) effect of crude oil pollution of soil and amelioration treatment on the growth parameters of eight varieties of cassava cuttings at 16 weeks of planting.

A. MS/97/4779.

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	27.0±0.69	12.2±1.10	1.0±0.11	17.5±2.10
2	21.5±1.02	9.7±0.86	0.8±0.22	13.8±1.52
4	21.0±1.00	8.8±0.10	0.7±0.11	11.2±0.91
6	18.4±2.40	8.1±0.52	0.5±1.00	10.7±1.32

B. TME/419

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	34.0±0.21	12.5±0.77	2.1±1.00	26.6±0.11
2	26.8±0.10	10.6±0.17	2.1±1.00	26.6±0.27
4	24.2±0.06	8.0±0.81	1.2±2.10	23.6±o.14
6	12.5±1.00	6.8±0.11	0.7±0.89	21.9±0.10

C. TMS/98/0057

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	61.0±0.65	23.3±0.71	2.3±0.88	15.1±0.00
2	46.6±0.24	18.8±0.82	2.0±0.19	13.1±0.87
4	39.9±0.81	16.6±0.17	1.4±1.00	11.2±1.22
6	28.1±0.11	12.8±1.00	1.6±1.00	8.0±1.00

D. NR 8082

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	39.6±0.11	15.6±1.11	2.3±0.01	22.0±0.25
2	28.0±0.01	12.1±1.23	1.9±0.86	17.0±0.67
4	30.4±0.20	13.2±0.89	1.7±1.00	14.9±2.00
6	14.0±1.00	5.4±1.00	1.1±1.11	13.8±1.87

E. TMS/30572

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	79.9±0.88	24.4±2.00	2.5±0.08	14.0±1.00
2	*86.0±1.00	23.9±1.88	3.0±1.23	14.8±2.11
4	68.0±0.00	23.1±1.67	2.2±1.02	12.7±1.09
6	67.9±1.22	23.4±0.05	1.9±0.72	12.2±0.88

F. TMS/97/0505

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	54.0±0.11	21.4±2.16	3.5±1.22	10.4±0.22
2	*58.2±0.87	19.0±1.89	3.8±0.01	13.8±1.87
4	47.1±1.55	19.8±1.77	2.6±2.28	12.5±1.00
6	45.1±1.00	19.7±0.89	2.6±1.91	10.4±0.81

G. TMS/92/0323

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	50.30±3.01	20.70±1.47	2.8±o.81	19.03±0.62
2	41.20±0.87	17.50±0.89	2.3±0.94	17.92±0.10
4	32.80±1.00	14.80±2.10	1.7±0.11	15.40±0.07
6	25.00±1.81	11.50±1.00	1.6±1.00	8.60±1.00

H. TMS/96/0581

Crude oil conc. (%)	Plant height (cm)	Petiole length (cm)	Internode length (cm)	Leaf area (cm^2)
0	72.90±2.81	23.71±0.07	2.4±1.07	10.14±1.00
2	*76.44±1.89	19.90±2.84	2.4±0.00	14.82±0.67
4	48.42±1.00	18.71±1.08	1.8±1.22	12.52±1.00
6	34.32±1.11	16.20±1.96	1.4±0.81	10.50±0.88

Table-3: Mean (± sd) effect of crude oil pollution of soil and amelioration treatment on the growth rate of primary and secondary roots at sixteen weeks.

S.No.	Variety	Crude oil conc. (%)	Primary roots (cm)	Secondary roots (root tubers)
1	TMS/97/4779	0	20.60±1.20	1
		2	21.21±1.89	-
		4	23.20±1.00	-
		6	13.70±1.01	-
2	TME/419	0	22.80±1.11	-
		2	23.61±0.60	-
		4	20.72±0.88	1
		6	19.00±1.00	1
3	TMS/98/0057	0	22.62±0.55	2
		2	19.66±1.10	-
		4	22.21±0.60	-
		6	20.73±0.45	-
4	NR 8082	0	17.88±0.01	-
		2	16.76±0.11	-
		4	13.00±1.11	-
		6	10.42±1.23	-
5	TMS/30572	0	20.44±1.00	*4
		2	20.65±1.86	*4
		4	21.89±1.22	*4
		6	21.48±1.11	*5
6	TMS/97/0505	0	24.18±1.81	*3
		2	23.83±1.23	*3
		4	24.68±1.12	*4
		6	25.42±0.11	*3
7	TMS/92/0323	0	18.88±1.66	1
		2	17.65±0.01	-
		4	16.68±0.10	-
		6	12.41±1.15	-
8	TMS/96/0581	0	26.68±1.22	*2
		2	30.84±1.87	*3
		4	28.24±1.52	*3
		6	25.34±1.00	*3

Table-4: Effect of crude oil pollution of soil and amelioration treatment on the level of some trace elements on the improved varieties of cassava leaves.

S.No.	Leaf samples	Zn. mg/l	Fe. mg/l	Pb. mg/l	Ni. mg/l	Cr. mg/l	Cd. mg/l
1	TMS/30572						
	0	18.24	98.55	8.36	6.36	0.30	<0.01
	2	16.45	82.47	5.27	10.25	0.38	0.02
	4	14.86	68.49	6.88	5.88	0.36	0.02
	6	*20.46	*99.34	7.54	*6.84	*0.39	<0.01
2	TMS/97/0505						
	0	15.92	79.46	9.73	4.87	0.18	0.01
	2	18.27	63.52	8.94	6.38	0.32	0.04
	4	14.73	58.22	6.58	5.39	0.25	0.01
	6	*18.39	47.39	8.26	*6.15	0.17	<0.01

3	TMS/96/0581						
	0	15.84	81.57	6.98	6.22	0.23	0.03
	2	*22.51	58.96	5.92	4.77	0.19	<0.01
	4	*19.23	39.44	*7.26	4.19	0.24	<0.01
	6	*16.47	79.26	*8.13	6.08	0.18	0.02

DF= X100

There were growth stimulations in some varieties at the concentration of 2%. These results are in line with the study of Pal and Overcrash [15] and Sam *et al.* [17] who reported that very low hydrocarbon may actually stimulate plant growth and crop yield. This may be due to the petroleum components acting as growth enhancement and may also occur in response to the humus content and water holding capacity of soil that have been affected by an oil contaminated incidents [15]. The reduction of growth parameters in TMS/98/0323, TMS/97/4779, TME/419, TMS/98/0057 and NR8082 may be due to high toxicity of the petroleum products used on the stem cuttings causing poor aeration of the soil because of the displacement of air from the spaces between the soil particles and the crude oil [16].

CONCLUSION

In this study, crude oil pollution of soil affected varieties differently, e.g, the crude oil was less toxic to the improved varieties (TMS/30572, TMS/97/0505 and TMS/96/0581) while it was highly toxic to other varieties. The result is in-line with the study of Sayles *et al.* [18], and Essien *et al.* [9] who reported that oil concentrated soil treated with organic supplements was less toxic to lettuce, corn and wheat root and shoot elongation.

Total nitrogen and plant trace elements were higher in polluted plants than the control. This result is in line with the report of Akaniwor *et al.* [1] who found that the levels of some trace elements such as Fe, Zn, Pb and Cd in heat processed staple food cultivated in oil producing areas were higher than those in non-oil producing areas. These levels of trace elements were indication of extensive pollution.

However, there is every indication that nutrient supplementation of oil polluted soil especially with organic nutrient sources is beneficial for cassava growth because the C/N ratio was narrowed.

This study showed that crude oil has resulted in contamination of soil and brought about waste of land, which diminished agricultural practices due to their toxic effects in the soil. Hence farmers are advised to plant improved varieties such as TMS/30572, TMS/97/0505 and TMS/96/0581 and such soil should be amended with organic supplements to reduce the toxicity of crude oil pollution.

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