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Effect of Crude Oil-Contaminated Soil on Germination and Growth Performance of *Abelmoschus esculentus* L. Moench—A Widely Cultivated Vegetable Crop in Nigeria

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ABSTRACT

This study investigated the effect of crude oil-contaminated soil on the germination and growth performance of *Abelmoschus esculentus*, a widely cultivated vegetable crop in Nigeria. The experiment was conducted in the Screen House, under controlled environmental conditions. The seedling emergence percentage, heights and girths were studied to determine the growth performance of the crop in crude oil-contaminated soil. The result of the investigation revealed that the crude oil-contaminated soil affects the growth performance of *Abelmoschus esculentus* L. as hindered germination, reduced heights and girths were observed in the crop planted in treated soil and this adversely and severely affects the crop agronomic growth and development and probably its yield. Therefore, contamination of agricultural soils with crude oil should be avoided and public awareness should be created on the detrimental effects of crude oil pollution in our terrestrial ecosystem. Innovative and environmental-friendly remediation strategies should be carried out on our agricultural soils that have been grossly polluted by crude oil exploitation and exploration.

Keywords: Soil; Contamination; Crude Oil; Growth Performance; *Abelmoschus esculentus*

1. Introduction

Environmental pollution is a common hazard in the Niger Delta Region. It is largely due to crude oil exploration and exploitation in the area. The activity of man associated with crude oil well drilling on agricultural land has its economic disadvantage on the communities where the crude oil are dug. This environmental pollution resulting from the crude oil drilling has put so many food crops at considerable risk. The crude oil contamination has serious damage on the physiological, anatomical and growth performance of plants, soil components and aquatic ecosystems. Soil is the most valuable component of the farming ecosystem and environmental sustainability largely depends on proper soil management. Sustainable use of agricultural soil on which plants depend is absolutely necessary for agricultural productivity. Soil pollution by crude oil and other petroleum products are presently a menance in Nigeria.

Oil pollution in whatever form is toxic to plant and soil micro-organism [1,2]. Previous studies by [3] had described that oil spills kill agricultural plant or inhibit the growth performance of the entire vegetation cover. Plants have been described as the first victims of oil spill on land ecosystem [4]. [5] reported that oil in soil creates unsatisfactory conditions for plant growth probably due to insufficient aeration of the soil. Oil readily penetrate the pore space of terretrial vegetation following any spill [6] with heavier friction which may block the pores and this subsequently impedes photosynthesis and other physiological processes in plant [7].

Although, crude oil spills is common in the Niger Delta region, impact of this menance has not been properly studied on the production of vegetables including Abelmoschus esculentus L. *Abelmoschus esculentus* (okra) is an errect, semi-woody herbeaceous annual crop of the family Malvaceae. It is widely grown in the tropics and highly variable in growth from less than 1 m to over 3 m in height. The flowers are yellow and purple and finger-like fruit occurs at the leaf axis. It is ubiquitously cultivated in Nigeria. Though recognised to be capable of germinating on a wide variety of soils, a well drained loamy soil is optimum for its growth. Research report had it that leaves and fruits of okra plant are eaten fresh and fried as pot-herb. Okra is an important herb in the

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treatment of Ulcers. The fruits are rich in minerals and vitamins while the stem bark yields fibre. Consequence on these immense domestic and medicinal values of *Abelmoschus esculentus*, this study is aimed at investigating the effects of crude oil-pollution on its germination and growth performance.

2. Materials and Method

The study was conducted in the Screen House of the Department of Biological Sciences, Niger Delta University, Wilberforce Island, Nigeria between March and April 2011. Wilberforce Island, (4˚58'N; 6˚06'E) is an extensive Island in Bayelsa State dominated by fresh mangrove forest vegetation. It has tropical humid hot climate with two seasons: a relatively cool rainy season which lasts between March and October and hot dry season between November and February. Wilberforce Island enjoys abundant annual precipitation of 2000 mm and it is 45 m above sea level.

The seeds of Okra were purchased as a single batch from local market in Amassoma. These seeds were soaked in distilled water for 24 hours before planting to break its dormancy. Top-loamy soil used in the study was collected from a 4-year fallowed plot in the University Research Farm, within a depth of 5 cm while the crude oil type "Bonny light" used was obtained from Shell Petroleum Development Company (SPDC), Port-Harcourt. Floating method, according to [8], was used to determine the viability of the okra seeds used in this experiment. 100 seeds were soaked in a water bath that contained distilled water for a period of 30 minutes, the seeds that submerged were 85 seeds, those that floated were discarded and 75 seeds were selected at random from the 85 seeds that submerged for the study.

Twenty five planting bags were filled with the topsoil from the location earlier described. The planting bags with a uniform weight of 2 kg each were arranged in the Screen House, the planting bags were divided into 5 groups. Each group consisted of five planting bags arranged in rows. The groups were labeled as treatment SHcontrol, SHA, SHB, SHC and SHD and replicated five times. The replicates of each treatment were treated with crude oil of varying concentration as 0 ml, 1 ml, 2 ml, 3 ml, and 4 ml for SHcontrol, SHA, SHB, SHC and SHD respectively.

All the treatments and the control planting bags were watered using 50 ml of water for three consecutive days, at 7:00 GMT. After this, three okra seeds were planted in each of the planting bag in all the treatment and the control experiment. Watering was continued daily at 7:00 GMT. The seedling emergence in the treatments and the control experiment was observed and recorded. Seedling emergence percentage in each treatment was calculated, according to [9] as:

$$\text{Emergency percentage}(\text{E}\%) = \frac{\text{Number of seedling that emerged} \times 100}{\text{Total number of seed sown}}$$

The co-efficient of velocity (COV) of germination in each treatment was determined according to [10,11] as:

$$\text{Co-efficient of velocity}\ (\text{COV}) = \frac{A_1 + A_2 + \cdots + A_5}{A_1T_1 + A_2 + A_2T_2 \cdots + A_5T_5} \times 100$$

where A is the numbers of seeds germinating and T is the number of days taken to germinate.

Records of seedling heights and girths in each treatment were taken weekly for 3 weeks after planting (3WAP) has been done in each treatment. The seeding girth was taken by means of Vanier Caliper while the height of the seedling was taken with the aid of meter rule. Mean value of the girths and heights in each treatment were taken and recorded. The experiment was terminated at 3WAP due to the death of the plants.

3. Results

The results of this experiment show marked different between the plants grown in crude oil-polluted soil and non-crude oil-polluted soil. *Abelmoschus esculentus* planted in soil treated with oil started germinating after 6 days compared to 4 days for plants in untreated soil (control). **Table 1** shows the effect of the crude oil on the seedling emergence (E%) and co-efficient of velocity (COV) of *Abelmoschus esculentus*. 100% emergence was observed in the non-crude oil-polluted soil. There were significant different between the *Abelmoschus esculentus* grown in crude oil-polluted soil and non-crude oil-polluted soil at 5% level of probability. The seedling emergence (E%) and Co-efficient of velocity (COV) decreased as the oil concentration increased above 1 ml concentration. However, it was also observed that the leaves

Table 1. Seedling Emergence (E%) and Co-efficient of Velocity (COV) of *Abelmoschus esculentus* in crude oil-polluted soil.

Treatments	E%	COV*
(Concentration ml)		
0	100	100a
1	72	91.4b
2	68	86.6c
3	49	42.4d
4	41	38.2e

+Week after planting. *Means with the same letters in each column are not significantly different according to Duncan Multiple Range Test (DMRT) at 5% level of probability.

of *Abelmoschus esculentus* were yellow, some of the leaves dropped while complete shed off, stunted growth and some of the plant grown in soil treated with crude oil died before the 4th week after planting.

Table 2 shows the effect of different concentrations of crude oil on the seedling height of *Abelmoschus esculentus*. There were significant differences between the plant grown in non-crude oil-polluted soil and those grown in soils with varying concentrations of crude oil concentration. Statistical analyses revealed that plant grown in non-contaminated soil with crude oil performed better than those raised in the crude oil-polluted soil no matter the concentration of the oil. However, the performance of the plants in the soils polluted with crude oil is concentration dependent. The plants grown in soil with 1 ml concentration of crude oil performed better than those raised in soil contaminated with 4 ml of crude oil when compared statistically. Therefore the performance of the plants in crude oil-polluted soil is concentration dependent.

Table 3 shows the effect of different concentrations of crude oil on seedling girth of *Abelmoschus esculentus*. All the seedling girths in the crude oil-polluted soils were stunted with reduced girth when compared with the plants grown in non-crude oil-polluted soil. However, the reduction in the seedling girths were depends largely on the crude oil concentration of the soils on which they were grown.

Table 2. Seedling Height of *Abelmoschus esculentus* in crude oil-polluted soil.

Treatment	Seedling heights (cm)/WAP+		
(Concentration %)	1	2	3
0	7.5 ± 0.28	10.1 ± 0.42	14.2 ± 0.44a
1	7.4 ± 0.29	10.4 ± 0.4	13.0 ± 0.38b
2	3.8 ± 0.21	4.8 ± 0.26	7.2 ± 0.38c
3	0	3.8 ± 0.25	4.1 ± 0.20d
4	0	3.9 ± 0.20	4.8 ± 0.26d

+Week after planting. *Means with the same letters in each column are not significantly different according to Duncan Multiple Range Test (DMRT) at 5% level of probability.

Table 3. Seedling Girths of *Abelmoschus esculentus* in crude oil-polluted soil.

Treatment	Seedling girths (mm)/WAP+		
(Concentration %)	1	2	3
0	0.20 ± 0.01	0.22 ± 0.01	0.25 ± 0.02a
1	0.18 ± 0.00	0.20 ± 0.01	0.24 ± 0.01a
2	0.14 ± 0.00	0.17 ± 0.00	0.20 ± 0.01a
3	0	0.11 ± 0.00	0.14 ± 0.00b
4	0	0.10 ± 0.00	0.10 ± 0.00b

+Week after planting.*Means with the same letters in each column are not significantly different according to Duncan Multiple Range Test (DMRT) at 5% level of probability.

4. Discussion

Soil is the most important component of the farming ecosystem and environmental sustainability largely depends on proper soil maintenance and management. Sustainable use of soil on which agriculture depends is absolutely necessary for an optimal agricultural productivity. Soil pollution by crude oil has poses a great menace to agricultural productivity and thus create poverty and hunger among the populace. It was observed from this experiment that oil in agricultural soil affects agricultural productivity. Oil pollution in agricultural soil in whatever form is toxic to the plant and soil microenvironments. It has been observed by several researchers [1,2,8,12] that crude oil affects agricultural soil and this in turns affect the physiological, ecological and anatomical development of plants grown on such soils and this in consonance with the outcome of the present studies. Germination of *Abelmoschus esculentus* (Okra) plant was delayed in crude oil polluted soil, though this effect was concentration dependent. This is in agreement with the result obtained by [2] that oil in soil above 2% concentration affects the growth of okra adversely and severely. Crude oil spill into agricultural soil therefore affects the germination, plant physiology and ecology and ultimately the growth and anatomical development of okra planted in the field. The presence of crude oil in the plant-soil microenvironment appears to affected normal soil chemistry wherein nutrient release uptakes as well as amount of water available to the plant are reduced [13]. The decrease in heights and girths of plant in crude oil-polluted soil may be due to the non-availability of adequate water, which possibly affected the nutrient uptake and mobility. This study thus, shows that artificial introduction of crude oil on agricultural soil has considerable adverse and severe effects on the germination, plant physiology and ecology as well as agronomic growth and development of some vegetable crops particularly *Abelmoschus esculentus* (Okra) in the Niger Delta region.

5. Conclusion

This study had revealed that introduction of crude oil into agricultural soil adversely and severely inhibits agronomic growth and development of *Abelmoschus esculentus* and reduces its height and girth. This will probably adversely affect the yields from the plant. Therefore, contamination of agricultural soils with crude oil should be avoided and public awareness should be created on the detrimental effects of crude oil pollution in our terrestrial ecosystem. Innovative and environmental-friendly remediation strategies should be carried out on our agricultural soils that have been grossly polluted by crude oil exploitation and exploration.

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