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Crude oil pollution on germination and growth properties of okra (*Abelmoschus esculentus*): Implications for food security

***EDE, E. Lemy, EKU, Gift and AGBOSA, T. Roseline**

Department of Science Laboratory Technology, Faculty of Science, Delta State University, Abraka, Nigeria.

*Corresponding author. Email: lemy.ede@delsu.edu.ng.

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Over the years, there has been several responses and activities to curb the issues of crude oil discharge on the environment. However, the issue of oil exploration and discharge still persist, resulting in environmental contamination and subsequently affecting agricultural activities and threats to food security. Therefore, the aim of this study is to investigate the effect of varying concentrations of crude oil on the germination and growth properties of *Abelmoschus esculentus* (okra). Varying concentrations of crude oil concentration in soil (15, 25 and 50% weight/volume) and control (water) was used for the study. The experimental design was complete randomized design (CRD) replicated three times. The results showed that 50% w/v crude oil treated soil had 19.7% germination rate while 15% w/v (73.1%), 25% w/v (51.2%) and the control (94.2%) germination. The results also showed that the higher the concentration of crude oil in the soil, the lower the plant height, with the highest value (38.7 cm) recorded for control (% treatment). The soil treated with the 50% w/v concentration recorded 3.0 in terms of number of leaves formed and 0.3 cm^3 circumference. The results provide sufficient evidence that crude oil pollution significantly impacts the early stages of plant development and overall growth and productivity of okra. The germination rate and seedling emergence were notably inhibited by crude oil pollution, resulting in reduced seed viability and hindered seedling establishment. The study recommends environmental monitoring and awareness to curb the menace of crude oil on crops.

Keywords: Crude oil, exploration activities, okra, growth properties, food security.

INTRODUCTION

Crude oil pollution has been shown to have negative effects on the environment, including on plant growth and germination. It contains toxic compounds such as polycyclic aromatic hydrocarbons (PAHs), heavy metals and volatile organic compounds (VOCs), which can have toxic effects on plants. These toxic compounds can enter plants through their roots, leaves, and stems, and can cause a range of physiological and biochemical changes that affect plant growth and development (Sharma *et al.,* 2024).

The extent of crude oil pollution's negative impact on plant growth and germination depends on factors such as the concentration of the crude oil, the duration of exposure, and the plant species. The exposure of plants to crude oil has been known to result in various physiological and morphological changes that can lead to a decrease in plant growth and yield (Bhattacharyya *et al.,* 2019; Kuppusamy *et al*., 2018). *Abelmoschus esculentus* (okra) is a highly nutritious vegetable that is widely cultivated in many parts of the world. Some plant species may be more tolerant of crude oil pollution than others. However, in general, crude oil pollution can reduce plant growth, inhibit germination, and decrease the overall productivity of agricultural crops (Kavamura and Esposito, 2010).

Several studies have been conducted to investigate the

impacts of crude oil on plant growth and germination, including okra. For example, Oyedeji *et al.* (2012) examined the effect of crude oil pollution on the germination and growth of okra, and found that crude oil pollution significantly reduced seed germination, shoot length, root length, and biomass production of the crops. Similarly, Adeyemi and Onwosi (2018) investigated the effects of crude oil on the growth, biochemical constituents, and yield of okra and observed that crude oil pollution caused a reduction in plant height, leaf area, fresh weight, dry weight, and yield of the crop. Oyinba *et al.* (2024) also assessed the impact of crude oil pollution on the growth of okra and *Amaranthus hybridus* and reported that crude oil pollution significantly reduced the shoot and root lengths, as well as the biomass of the crops.

The Niger Delta region of Nigeria has been identified as one of the most polluted areas in the world due to the activities of the oil industry, and this has led to the degradation of the soil and the loss of biodiversity. Okra (*Abelmoschus esculentus*) is an important crop in the region, and its growth and yield may be affected by crude oil pollution. In recent times, research has halted on the investigations into the ravaging effects of crude oil in the environment and how it affects food security. Due to its potential negative impact on the environment and human health, crude oil pollution is a major concern worldwide. It is therefore important to study the effect of crude oil pollution on plant growth and germination continuously to inform sustainable agricultural practices and environmental management strategies. Therefore, there is a need to investigate the effect of crude oil pollution on the germination and growth properties of okra under field conditions.

MATERIALS AND METHODS

Study area

This experimental research was carried out in Site III of Delta State University, Abraka. The experiment was set up at the Department of Science Laboratory Technology, Faculty of Science, Delta State University, Abraka, Delta State. Abraka lies between Latitude 05°47'N and Longitude 06°06'E of the equator with an annual rainfall of 3,097 mm, annual relative humidity of 83/c and annual mean temperature of 30.6°C.

Soil preparation and crude oil treatment concentrations

The soil sample was homogenized at the laboratory before commencement of the experiment. Two grams of soil was weighed into polyethylene bag perforated at the bottom to allow water percolate through to the soil. The contamination of soil samples with crude oil was done by thoroughly mixing the soil with different concentrations of crude oil in their respective plastic buckets (Erhenhi *et al.,* 2019). Soil of 2 kg in each of the plastic buckets was treated with different crude oil treatment concentrations (15, 25 and 50%) and control (water) were used for the study.

Seed planting

Seeds were planted on soil samples contaminated with the treatments after one week. The soil samples were watered continuously before and after planting and monitored for a period of 28 days before measurement were taken on intervals of two days.

Determination of percentage germination

Percentage germination was determined as described by Agbogidi and Ogbe (2025), with the formula:

$$\% \text{ germination} = \frac{\text{Number of seedlings that sprouted over}}{\text{Number of seeds planted}} \times 100$$

Determination of plant growth parameters

Height of plant was measured using a tape from the base to the tip of the plant, leaf number of the plants were manually counted while the circumference was taken by wrapping the tape across the plant. All parameters were recorded in replicate and at 2 days interval.

Statistical analysis

Data obtained were computed using Microsoft Office Excel (Version 21). Analysis of variance (ANOVA) was used to compare variation between treatment while Duncan Multiple Range (DMR) test was used to separate means at $P \leq 0.05$ level.

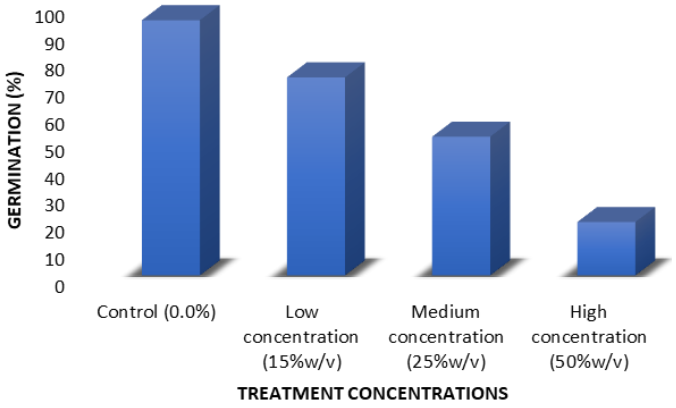

Figure 1. Percentage germination of okra (*Abelmoschus esculentus*) plant in soil treated with varying concentration of crude oil.

RESULTS

Percentage germination

The effect of varying concentration of crude oil on percentage germination of okra (*Abelmoschus esculentus*) in potted field experiment is shown in Figure 1. The results showed that there was significant difference ($P \leq 0.05$) between the treatments and control as observed from 2 weeks after planting. Germination result shows that

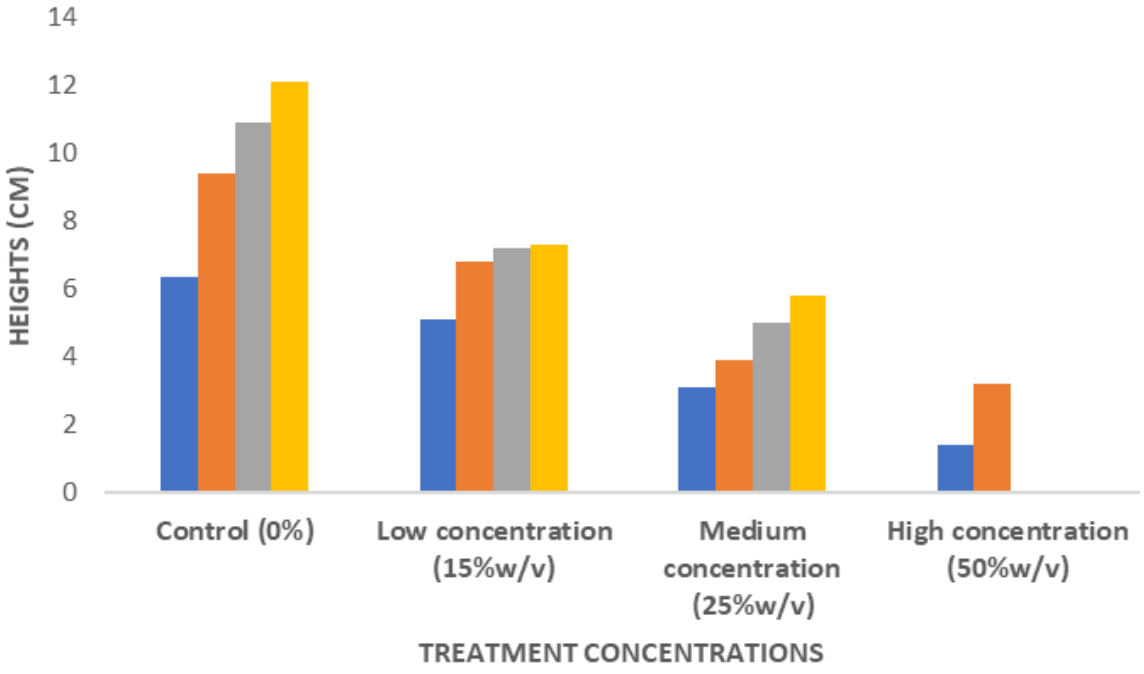

Figure 2. Plant height of crude oil contaminated okra (*Abelmoschus esculentus*) plants in soil treated with varying concentration of crude oil.

the control (water) had the highest value (94.2%) for percentage germination. This was followed by 15% w/v treatment (73.1%) and 25% w/v crude oil concentration soil (51.2%) while soil treated with 50% w/v crude oil had the lowest germination rate (19.7%).

Growth indices

Measurement of the plant height of *Abelmoschus esculentus* contaminated with different concentration of crude oil in potted field experiment is shown in Figure 2. The results showed statistical difference ($P \leq 0.05$) across the various treatment concentration after two weeks of planting. The values obtained showed that the higher the concentration of crude oil in the soil, the lower the plant height, with the highest value recorded for 0% (control). Soil treated with 50% w/v recorded 4.6 cm in height which was significantly different ($P \leq 0.05$) from the result obtained from the control (38.7 cm) and 15% w/v treatment (26.5 cm).

Figure 3 shows the effect of different concentration of crude oil on numbers of leave formed by *Abelmoschus esculentus* plant in potted field experiment. The results showed that there was significant difference ($P \leq 0.05$) across the different treatment and control. The highest leaf number of 19.6 was recorded in the control, this was followed by 15% w/v treatment (14.8) and 25% w/v treatment (11.6) while the least number of leaves formed was recorded for 50% w/v treatment (3.0).

DISCUSSION

The results of this study are consistent with previous research on the effects of crude oil on plants. The germination rate of okra seeds was significantly affected by the varying concentrations of crude oil in the soil. In the control treatment without oil pollution, the germination rate was 94.2% while the lowest treatment (15% w/v) recorded 73.1% germination. However, as the concentration of crude oil increased, the germination rate decreased significantly. At the highest concentration of crude oil (50% w/v), the germination rate was reduced to 19.7%. This result correlates with the study of Adeyemi and Onwosi (2018).

This reduction in germination rate can be attributed to the toxic compounds present in crude oil, such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals, which can inhibit seed germination and early seedling growth. The presence of crude oil on the seed surface may also interfere with water absorption and gas exchange further. Similar to the germination rate, the emergence of okra seedlings was adversely affected by crude oil pollution. This is in line with the studies of Hassan et al. (2018) and Oyinba et al. (2024). The inhibition of seedling emergence can be attributed to the inhibitory effects of crude oil on root growth and elongation. The toxic compounds present in crude oil can damage the delicate root tissues, impede root development and hinder seedling emergence from the soil (Maiangwa and Bala, 2019).

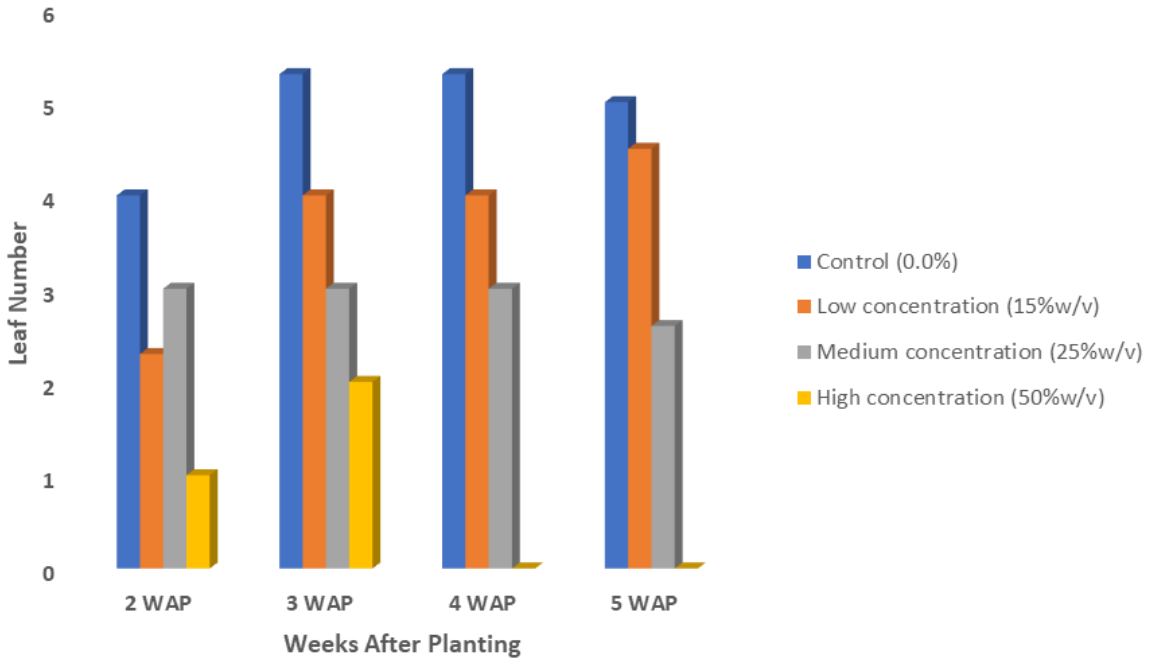

Figure 3. Number of leave formed per plant of okra (*Abelmoschus esculentus*) plant in soil treated with varying concentration of crude oil.

The difference in growth, in terms of plant height and leaf area between the control and treatment could be attributed to several factors (Erhenhi *et al.,* 2019). At the physiological level, crude oil pollution can affect the plant's ability to carry out photosynthesis, respiration, and transpiration. This can result in a reduction in the growth and development of the plant, as well as a decrease in its ability to produce biomass and yield. (Skrypnik *et al.,* 2021). At the biochemical level, crude oil pollution can affect the plant's metabolic processes by disrupting enzyme activity and altering the production of various biochemicals such as pigments, carbohydrates, and proteins. Crude oil pollution can also lead to the accumulation of toxic compounds in plant tissues, which can further exacerbate the toxic effects on the plant. (Khaliq *et al.,* 2022).

Conclusion

The study aimed to investigate the effect of varying concentrations of crude oil on the germination and growth properties of okra (*Abelmoschus esculentus*) as it affects food security. The results provide compelling evidence that crude oil pollution significantly impacts the early stages of plant development and overall growth and productivity of okra. The germination rate and seedling emergence were notably inhibited by crude oil pollution, resulting in reduced seed viability and hindered seedling establishment. This investigation is a follow-up study, to crave indulgence of the government and other relevant bodies that crude oil still has negative effects on crops and food security. Hence, monitoring efforts should involve collaboration between environmental agencies, research institutions, and local communities.

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Conflict of Interest

Authors declare that there is no conflict of interest in any form that will influence the outcome this study.

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