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ORIGINAL ARTICLE

RESPONSE OF MAIZE VARIETIES SAMMAZ 31 AND SEEDCO 419 (*ZEA MAYS* L.) TO USED ENGINE OIL CONTAMINATION IN LOAMY SOIL: GERMINATION AND GROWTH

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ABSTRACT

In the present study, the impact of Used Engine Oil (UEO) contamination was assessed on seed germination, seed viability, tolerance of stress, and vegetative growth parameters of maize varieties SAMMAZ 31 and SEEDCO 419 in loamy soil. The study was conducted in August – September, 2025 at Sa'adu Zungur University, Nigeria. Seeds were sown in soil, amended with 0, 200, 400, and 800 g/kg UEO under a completely randomized design with three replicates. Seed germination and seedling survival were monitored for 21 days, while plant height, leaf number, fresh weight, and dry weight were measured. The macronutrient and micronutrient levels of soil were analyzed before and after the treatment using Atomic Absorbance Spectroscopy. Results revealed that increasing UEO concentrations significantly inhibited germination and seedling survival, with SAMMAZ 31 showing greater tolerance than SEEDCO 419. Vegetative growth metrics declined dose-dependently, exacerbated by elevated

heavy metal concentrations (Cu, Zn, Mn, Fe) and nutrient imbalances, notably deficient calcium and excessive potassium and sodium. Despite no statistical significance in ANOVA tests, these reductions indicate strong phytotoxicity from UEO contamination. The study concludes that UEO pollution severely impairs maize establishment and growth, with varietal differences highlighting the potential for selecting tolerant cultivars like SAMMAZ 31 in contaminated environments. It recommends avoiding cultivation on heavily polluted soils, employing tolerant varieties, regular soil monitoring, implementing remediation and phytoremediation strategies, and promoting responsible UEO disposal to protect agricultural productivity and environmental health.
Keywords: Maize varieties, used engine oil, contamination, loamy soil, germination.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most widely cultivated cereal crops globally, serving as a staple food, animal feed, and raw material for industrial products (Worku *et al.,* 2020; Chola *et al.,* 2025; Robert *et al.,* 2025; Ngala *et al.,* 2025; Yu *et al.,* 2025). It's recognized globally for it is versatility and high production potential at varying environmental condition (Saritha *et al.,* 2020; Ngala *et al.,* 2025). Moreover, its adaptability to diverse agro-climatic conditions and high yield potential make it indispensable in food security (Janke, 2017). Among the many maize varieties, Sammaz 31 and Seedco 419 are elite cultivars known for their favorable agronomic traits, including yield stability and adaptability to local farming systems (Senior Research Fellow, 2025; Nigerian Seed Portal Initiative, 2025).

Previous studies focused on understanding the responses of these varieties with emphasis on yield and disease resistance (Oyekunle *et al.,* 2019; SeedCo Zambia, 2022; SeedCo Group, 2024; Nigerian Seed Portal Initiative, 2025), while their responses to environmental stresses, such as soil contamination remain scarce, and understanding such is crucial for sustaining maize production and improving crop management strategies.

The maize seed comprises several key structures essential for successful germination and early growth. At the core is the embryo, containing the radicle (embryonic root), plumule (embryonic shoot), and coleoptile (protective sheath that covers the shoot tip as they emerge from the soil), all enveloped by the seed coat and nourished by the endosperm, which stores nutrients to support initial growth. These structures are dependent upon certain factors that determine their emergence from seeds; they include physical, chemical, physiological, molecular and environmental factors (Ramlal *et al.,* 2025).

Seed germination is an important physiological process in agronomic practice as it initiates the establishment of seedlings in the agricultural field (Reed *et al.,* 2022; Ramlal *et al.,* 2025). Germination begins with imbibition, where the seed absorbs water causing cell expansion and metabolic activation leading to the emergence of radicle and cotyledons (Yan & Chen, 2020; Ramlal *et al.,* 2025), while seminal and nodal roots subsequently develop to establish the seedling's root system, facilitating nutrient and water uptake necessary for vigorous growth.

Furthermore, seed germination testing is important in the process of plant growth (Yuting & Yuji, 2021; Sera & Hnilicka, 2023; Yu *et al.,* 2025), especially in a contaminated soil environment as there a high tendency of germination failure and successful seedling growth.

Seed germination status is also crucial in in-depth understanding of germination rate and potential of maize seeds at varying agronomic field condition. This is an important guide for farmers and other growers to select quality soil with high potential to support growth, better yield and high-quality seed production (Divya Venkata *et al.,* 2023; Zhang *et al.,* 2023; Yu *et al.,* 2025), while addressing the soil with poor qualities and it is caused for proper action, thereby improving the agricultural activities.

Used engine oil (UEO) is a brown-black mixture of heavy metal contaminants, low to high molecular weight aliphatic and aromatic hydrocarbons, polychlorinated biphenyls, chlorodibenzofurans, lubrication additives and composition products (Ngozi *et al.,* 2017), introduces complex physiochemical and biological disruption to soil ecosystem, adversely affecting seed germination and seedling growth (Alzway *et al.,* 2025). UEO contamination in agricultural soils is an increasing environmental concern due to improper disposal and accidental spillage (Onwusiri *et al.,* 2017; Ozomata *et al.,* 2022; Ataikiru & Okpako, 2024; Kawedo *et al.,* 2024). Similarly, previous studies have reported a lower rate of germination due to pollution by petroleum and its derivatives (Akuma, 2017; Alzway *et al.,* 2025). Moreover, this pollutant contains a complex mixture of hydrocarbons, heavy metals contents of used engine oil contaminated soils imposes metabolic disorder, added toxic additives that degrade soil physicochemical properties, and inhibits growth on most plant species, which hinders germination, reduce crop yield and lead to premature death of plant (Akuma, 2017; Ngozi *et al.,* 2017; Odiyi *et al.,* 2020; Nwachukwu *et al.,* 2020; Kawedo *et al.,* 2024; Ataikiru & Okpako, 2024; Alzway *et al.,* 2025).

The contamination of agricultural land and other vegetation by used engine oil presents serious challenges for monitoring and control, as it easily seeps into the environment, polluting water and soil (Onwusiri *et al.,* 2017; Kawedo *et al.,* 2024). Contaminated soils often exhibit reduced aeration, altered pH, and diminished microbial diversity, collectively impairing soil fertility (Ikuesan *et al.,* 2019; Chukwu *et al.,* 2024; Ataikiru & Okpako, 2024).

Such changes can adversely affect plant growth by limiting nutrient availability and disrupting water uptake, making it imperative to study the impact of used engine oil on crop performance, especially in widely cultivated grains like maize.

Previous studies indicate that used engine oil contamination negatively influences seed germination and seedling development in crops, including maize. Toxic compounds in the oil can inhibit enzymatic activities critical for germination and cause physiological stress leading to delays germination of seeds, reduced germination percentages, slower seedling emergence, diminished biomass and causes reduction in the growth of plants" (Adeleye *et al.,* 2018, Adeleye *et al.,* 2017, Azorji *et al.,* 2021; Ataikiru & Okpako, 2024). Mechanisms include obstruction of oxygen diffusion to seeds, moisture retention changes, and direct toxicity to embryonic tissues. These adverse effects compromise seed viability and vigor, ultimately affecting plant stand establishment and yield potential.

Investigating the responses of Sammaz 31 and Seedco 419 maize varieties to soil contaminants is significant due to their prevalence in local agriculture and potential genetic differences in stress tolerance. Varietal differences in germination and growth responses to pollutants like used engine oil can inform breeding programs and guide farmers in selecting resilient cultivars (Adebayo *et al.,* 2022). Such targeted studies fill knowledge gaps by connecting varietal adaptability with environmental challenges, thus enhancing sustainability and productivity in maize cultivation under pollution stress.

Despite existing literature on the effects of hydrocarbons on crop germination, limited information is available on how locally important maize varieties, such as Sammaz 31 and Seedco 419, respond to used engine oil contamination specifically in loamy soils. Loamy soil's unique texture influences water retention and pollutant interaction, affecting seed behavior distinctly from other soils. This study aims to assess the response of maize varieties Sammaz 31 and Seedco 419 (*Zea mays L.*) to used engine oil contamination in loamy soil, germination and growth to elucidate tolerance mechanisms and inform remediation and agronomic practices.

MATERIALS AND METHODS

Study Area

The study was conducted at the Biological Sciences Garden, Sa'adu Zungur University, Bauchi, located at latitude 11.82644167° N and longitude 10.16221833° E within Gadau town, Bauchi State. Gadau, the main town associated with the university's permanent site, lies in Bauchi State, northeastern Nigeria. It is a semi-urban settlement with a predominantly agrarian population engaged in farming and livestock rearing. The region's ecology and climatic pattern provide a suitable context for ecological and botanical research, particularly on plant adaptation and distribution within the savanna ecosystem. The site lies within the Sudan savanna zone of Nigeria, characterized by a tropical wet-and-dry climate (Aw) according to the Köppen classification. The area experiences a distinct rainy season from May to October, with an average annual rainfall of 900–1,000 mm, and a dry season from November to April, dominated by the dry northeast trade winds (Harmattan). Mean daily temperatures range between 26 °C and 34 °C, with relative humidity varying seasonally between 20% and 80%. The vegetation of the area is predominantly savanna woodland, composed of scattered trees such as *Azadirachta indica*, *Tamarindus indica*, and *Parkia biglobosa*, interspersed with grasses like *Digitaria spp.*, *Eragrostis spp.*, and *Andropogon species*, with the most dominant as *Andropogon gayanus*. Vegetation distribution reflects both natural and anthropogenic influences, including grazing, cultivation, and periodic burning, which shape the mosaic of grassland and shrub patches around the university environment.

Collection of Plant Materials and Used Engine Oil (UEO)

Maize seeds of two varieties, SAMMAZ 31 and SEEDCO 419, were obtained from the Bauchi State Agricultural Development Programme (BSADP) seed store. These seeds were selected based on their high yield potential, disease resistance, and adaptability to the local climate. Used engine oil was collected from the main mechanic workshop in Azare, Bauchi State, using a clean 1-liter container. The oil was then transported to the Science Laboratory Technology Laboratory at Sa'adu Zungur University for further analysis.

Preparation of Plant Materials:

The collected maize seeds were cleaned to ensure they were free from any dirt. Seed viability testing was conducted using the floating method as described by Ataikiru & Okpako (2024). Only viable seeds were retained, while non-viable seeds were discarded. The viable seeds were then packed in polythene bags and stored in a cool, dry place until planting.

Collection and preparation of Soil Sample

Soil samples were collected from a farm within Sa'adu Zungur University, Bauchi State, Nigeria. The soil type was loamy, consisting of a mixture of clay, silt, and sand. Samples were taken from the top 0–15 cm layer of the soil profile, following the method described by Ezenwa *et al.,* (2022). Soil type was confirmed by an expert from the Department of Soil Science, Faculty of Agriculture, Sa'adu Zungur University. Each sample was collected using a soil auger to minimize disturbance to the soil structure. The collected soil samples were air-dried for 48 hours to remove excess moisture. After drying, the samples were sieved through a 2 mm mesh to remove debris and stones. The sieved samples were thoroughly mixed to ensure uniformity (Adeko *et al.,* 2023) and then stored in clean, dry containers until used for the experiment.

Pre-and-post planting analysis of soil parameters

Before the soil was polluted with used engine oil, the macro-nutrient and heavy metal compositions of the prepared soil, both before and after planting, were determined using the standard method described by Lilly *et al.,* (2017) and Oladejo *et al.,* (2024). The nutrients analyzed included macro-nutrients such as potassium (K), sodium (Na), and calcium (Ca), while the heavy metals measured included copper (Cu), manganese (Mn), iron (Fe), and zinc (Zn).

Experimental design

The study was conducted using a completely randomized design (CRD) with three replicates. Used Engine Oil (UEO) concentrations of 200 g/kg, 400 g/kg, and 600 g/kg were each mixed thoroughly into separate sets of 1 kg loamy soil contained in sterilized containers to ensure homogeneity. Four treatments (200 g/kg, 400 g/kg, 600 g/kg, and 0 g/kg as the control) were prepared and distributed into twelve planting pots, each approximately 8 cm in diameter and containing 1 kg of soil.

Before planting, the soil samples were moistened with tap water to approximately 80% of the soil's water-holding capacity, following the method of Ezenwa *et al.,* (2022).

Data Collection

Measurement of Plant Growth Parameters: Germination in each pot was monitored daily for seven days, and the number of germinated seeds was recorded following the method of Ezenwa *et al.,* (2022). On the seventh day, the number of seedlings in each pot was reduced to one. Subsequently, growth parameters including plant height, leaf number, fresh weight, and dry weight were measured per plant in centimeters and documented, according to Singh *et al.*, (2017). The entire growing period of the study lasted for 21 days (three weeks).

Germination Percentage: Germination percentage was evaluated as the proportion of seeds that successfully germinated out of the total seeds sown in each experimental unit. This parameter quantifies the initial response of maize seeds to contaminated soil conditions and provides a foundational measure of viability and stress tolerance. In the current study, germination percentage allowed direct comparison of germination responses across both maize varieties and treatment conditions. It was calculated according to the methods described by Božena *et al.,* (2023) and Shah *et al.,* (2021).

$$\boldsymbol{G}\% = \left(\frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}}\right) \times 100$$

Survival Rate: Survival rate (%) denotes the percentage of maize seedlings that remained alive after the initial germination period, accounting for post-germination mortality due to soil contamination. This metric reflects the establishment success of seedlings in contaminated substrates and provides insight into the longer-term impact of used engine oil on maize seedling physiology. The formula for calculating survival rate is widely applied in restoration and stress physiology contexts. In this experiment, it was calculated according to the guidelines provided by the EPA, (2018) and Regreening Africa (2020).

$$\textbf{Survival Rate} = \left(\frac{\text{Number of surviving seedlings after 21 days}}{\text{Number of seedlings initially germinated}}\right) \times 100$$

Seed Compromised Percentage: Seed compromised percentage (%) quantifies the proportion of sown seeds rendered non-viable either by their inability to germinate or by showing symptoms of damage due to exposure to soil contaminants. This parameter is essential for monitoring sub-lethal seed injuries or failure to thrive, facilitating a nuanced assessment of the impacts of used engine oil. In this study, seed compromised percentage was calculated following the methods as described by Cechin *et al.,* (2023) and Božena *et al.,* (2023).

$$\textbf{Seed Compromised Percentage} = \left(\frac{\text{Number of seeds germinated but died before day 21}}{\text{Total number of seeds sown}}\right) \times 100$$

Data Analysis

Descriptive analysis was used to calculate the means and standard deviations of the growth parameters. Analysis of variance (ANOVA) was employed to compare the means of these growth parameters. Where significant differences were observed, Duncan’s Multiple Range Test (DMRT) was used to separate the means. All ANOVA analyses were conducted using SPSS Statistics (Version 20). Nutrient analysis for macro and heavy metals was performed using Atomic Absorbance Spectroscopy (AAS) calibrated at 1/1000 ppm.

RESULTS

Effect of different UEO concentrations on seed germination performance for SAMMAZ 31 and SEEDCO 419 in a loamy soil.

The results reveal that as Used Engine Oil (UEO) concentration in loamy soil increases, the seed germination performance of both maize varieties, SAMMAZ 31 and SEEDCO 419, declines markedly. Table 1 demonstrates that under low UEO contamination (200 g/kg), a portion of the seeds germinated successfully, though with some mortality, while at higher concentrations (400 and 800 g/kg), germination was severely inhibited or absent. The control condition without contamination shows full germination and seedling survival. This pattern underscores the toxic effects of UEO on seed viability and early growth stages.

Table 1. Effect of different UEO concentrations on seed germination performance for SAMMAZ 31 and SEEDCO 419 in a loamy soil.

	SAMMAZ 31					SEEDCO 419				
Concentrations	**SP**	**SG**	**SDG**	**SNG**	**ALV-21**	**SP**	**SG**	**SDG**	**SNG**	**ALV-21**
200g/kg	6(3)	6(3)	1(2)	0(0)	5(3)	6(3)	6(3)	4(8)	0(0)	2(1)
400g/kg	6(3)	4(2)	2(4)	2(1)	2(1)	6(3)	0(0)	0(0)	6(3)	0(0)
800g/kg	6(3)	0(0)	0(0)	6(3)	0(0)	6(3)	0(0)	0(0)	6(3)	0(0)
Control	6(3)	6(3)	0(0)	0(0)	6(3)	6(3)	6(3)	0(0)	0(0)	6(3)
Total	24(12)	16(8)	3(6)	8(4)	13(7)	24(12)	12(6)	4(8)	12(6)	8(4)

[The value outside the parenthesis *() is a number of replications, while the number within the parenthesis (*) is an average value, **SP**= Seed Planted, **SG**= Seed Germinated, **SDG**= Seed died after Germination, **SNG**= Seed not germinated and **ALV-21**= Seeds alive at 21 days respectively].

Seed viability, Seed tolerance to stress and Seed quality of SAMMAZ and SEEDCO 419 in a loamy soil contaminated with different concentrations of UEO.

Table 2 quantifies seed viability, tolerance to the stress of UEO contamination, and seed quality metrics for the two varieties. SAMMAZ 31 exhibits a higher germination percentage of 66.67% and better survival rate at 81.25% compared to SEEDCO 419's germination at 50% and survival at 66.67%, indicating a relatively stronger tolerance to UEO stress. However, SEEDCO 419 shows a higher seed compromised rate, reflecting more damage under stress conditions.

Table 2. Seed viability, Seed tolerance to stress and Seed quality of SAMMAZ and SEEDCO 419 in a loamy soil contaminated with different concentrations of UEO.

Varieties	SP	SG	SDG	ALV-21	GP (%)	SR (%)	SC (%)
SAMMAZ 31	24	16	3	5	66.67	81.25	37.5
SEEDCO 419	24	12	4	2	50	66.67	66.67
Total	48	28	7	7	58.33	75	50

(**SP**= Seed Planted, **SG**= Seed Germinated, **SDG**= Seed died after Germination, **ALV-21**= Seeds alive at 21 days, **GP (%)** = Germination Percentage, **SR (%)** = Survival Rate, and **SC (%)** = Seed Compromised respectively)

Vegetative growth parameters of SAMMAZ 31, and SEEDCO 419 under used Engine Oil contaminated Loamy soils.

Vegetative growth parameters measured and summarized in Table 3 show that plant height, leaf number, fresh weight, and dry weight all decrease as UEO concentration increases in the soil. The control condition consistently yields the highest growth values, while the 800 g/kg concentration shows no measurable growth. Among the two, SAMMAZ 31 generally performs better with greater plant height and biomass accumulation across UEO treatments, indicating better resilience. The ANOVA results for the effect of different concentrations of Used Engine Oil on plant height reveal an F statistic less than the critical value ($F < F_{crit}$) and a high *p-value* (0.27), indicating no statistically significant difference in plant height across concentrations. Similarly, for leaf number, with F below *Fcrit* and *p-value* 0.17, there is no significant difference in mean leaf numbers across the treatments. For fresh weight, though the F statistic is also below the critical value and the *p-value* is 0.55, this confirms no significant effect of UEO concentration on fresh weight. The dry weight results align with this pattern, with an F statistic less than the critical threshold and a *p-value* of 0.51, showing no significant difference in dry weight across concentrations.

Table 3. Means and Standard Deviations for vegetative growth parameters of SAMMAZ 31, and SEEDCO 419 under used Engine Oil contaminated Loamy soils.

	SAMMAZ 31				SEEDCO 419			
Concentrations	**PL**	**LN**	**FW**	**DW**	**PL**	**LN**	**FW**	**DW**
200g/kg	9.1±3.9	3.75±0.96	2.7±0.46	0.67±0.15	5.2±1.2	2.75±0.96	3.5±0.7	0.83±0.31
400g/kg	16.37±5.9	3.67±0.58	3.97±0.40	1.03±0.15	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
800g/kg	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Control	25.19±11.72	5.33±0.87	4.03±0.51	1.2±0.3	19.7±8.58	4.78±0.97	4.6±0.79	1.13±0.40

(**PL**= Plant Height, **LN**= Leaf Number, **FW**= Fresh Weight, **DW**= Dry Weight, the values underlined are the mean values while others not underlined are their respective standard deviation values).

Table 4: Soil Nutrients Analysis Results: Observed Levels (mg/kg) versus

Nutrient	Pre-Conc	Post-0g	Post-200g	Post-400g	Post-800g	Recommended Limit
Na	8.14	9.04	25.48	49.32	71.51	<100 (too high if ESP>15%), opt. 1–50
Ca	0.01319	97	102	105	125	1000–2500
K	0.00638	121	130	155	207	80–150
Zn	0.30115	13.2	13.4	13.7	14.27	1–3 (DTPA extractable)
Cu	28.9008	31.2	31.9	42.2	53.1	0.5–2 (DTPA extractable)
Fe	22.35	16.12	20.3	20.44	21.24	2.5–5 (DTPA extractable)
Mn	0.80346	93	97	100	121	2–10 (DTPA extractable)

(**DTPA**: Diethylene Triamine Penta Acetic Acid (use to extract available micronutrients from soil for testing), **ESP**: Exchangeable Sodium Percentage (in the soil), **Conc**: Concentrations)

Soil nutrients analysis results.

The following table compares the pre- and post-experiment soil nutrient concentrations obtained from soil analysis with the recommended limits endorsed by the Soil Science Society of America (SSSA), American Society of Agronomy (ASA), Crop Science Society of America (CSSA), International Union of Soil Sciences (IUSS), and British Society of Soil Science (BSSS). The recommended ranges are based on published guidelines for general agronomic soils. Pre-analysis values for most nutrients were well below the recommended thresholds, indicating prior deficiency, except for copper, which was already highly elevated. Potassium (K) levels increased markedly post-experiment, with all values exceeding recommended agronomic maxima at 400 g/kg and 800 g/kg UEO amendments, suggesting excess that could disrupt ion balance or cause antagonistic effects, although early values (0 g/kg and 200 g/kg) remained within the acceptable range. Sodium (Na) also rose in post-amendment samples, approaching levels warranting caution at higher treatments; however, all values remained below the general warning threshold of 100 mg/kg for most soils. Calcium (Ca) concentrations remained extremely low relative to best agronomic practices, far below optimum levels. Micronutrients including zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn) showed substantial increases in post-amendment soils, especially at higher contamination rates, greatly exceeding sufficiency and even toxicity thresholds recommended by SSSA, ASA, and CSSA. Elevated concentrations of these micronutrients may inhibit plant growth or pose toxicity risks, significantly surpassing standard safe or optimal limits (Table 4).

Effect of different UEO concentrations on vegetative growth parameters of SAMMAZ 31, and SEEDCO 419 under used Engine Oil contaminated Loamy soils.

The results in the table 5, 6,7 and 8 shows the analysis of variance (ANOVA) results for the comparison of plant height, leaf number, fresh weight, and dry weight responses to different used engine oil concentrations and maize varieties respectively.

Table 5. Comparison between Plant Height and Oil Concentrations. (Adj= Adjusted, Conc = Concentration)

Source	**DF**	**Adj SS**	**Adj MS**	***F-Value***	***P-Value***
Variety	1	189.9	189.87	4.38	0.041*
Oil Conc (g/kg)	3	5346.1	1782.03	41.15	0.000**
Error	58	2511.8	43.31		

Table 6. Comparison between Leaf Number and Oil Concentrations. (Adj= Adjusted, Conc= Concentration)

Source	**DF**	**Adj SS**	**Adj MS**	***F-Value***	***P-Value***
Variety	1	7.35	7.35	5.12	0.027*
Oil Conc (g/kg)	3	275.15	91.72	63.91	0.000**
Error	67	96.15	1.44		

In table 5, both variety and oil concentration significantly affect plant height, with oil concentration having a very strong effect ($p < 0.001$, R-squared: 68.81%). Variety A shows significantly taller plants than Variety B. Leaf number is significantly influenced by both variety and oil concentration, with oil concentration again showing a very strong effect ($p < 0.001$, R-squared: 74.61%). Variety A produces significantly more leaves compared to Variety B (Table 6). Oil concentration has a significant but lesser effect on fresh weight compared to height and leaf number ($p > 0.001$, R-squared: 11.60%). Variety effect is not significant (Table 7).

Table 7. Comparison between Fresh Weight and Oil Concentrations.

Source	**DF**	**Adj SS**	**Adj MS**	***F-Value***	***P-Value***
Variety	1	0.72	0.72	0.31	0.577
Oil Conc (g/kg)	3	19.40	6.47	2.82	0.045*
Error	67	153.41	2.29		

Table 8. Comparison between Fresh Weight and Oil Concentrations.

Source	DF	Adj SS	Adj MS	*F-Value*	*P-Value*
Variety	1	0.0939	0.0939	0.77	0.385
Oil Conc (g/kg)	3	0.8428	0.281	2.29	0.086
Error	67	8.22	0.123		

Neither variety nor oil concentration had statistically significant effects on dry weight, although there is a trend of reduction with higher concentrations ($p > 0.001$, R-squared: 10.23%) (Table 8).

DISCUSSION

Contamination of soil with used engine oil, hydrocarbon and their derivatives significantly affect soil nutrients and its ability to support plant growth and development. The result on the effect of different UEO concentrations on seed germination performance for SAMMAZ 31 and SEEDCO 419 in a loamy soil revealed that Used Engine Oil (UEO) contamination significantly reduced seed germination rates in both SAMMAZ 31 and SEEDCO 419 maize varieties, with higher concentrations (400 and 800 g/kg) causing near-complete inhibition of germination. This aligns with previous observations that hydrocarbon-based soil pollutants impair germination via toxicity and metabolic disruption (Adeleye *et al.*, 2017; Alzway *et al.*, 2025; Ataikiru & Okpako, 2024). Importantly, SAMMAZ 31 exhibited relatively better germination under low UEO contamination, consistent with varietal stress tolerance variability noted in maize (Oyekunle *et al.*, 2019; Worku *et al.*, 2020). Findings on Seed viability, Seed tolerance to stress and Seed quality of SAMMAZ and SEEDCO 419 in a loamy soil contaminated with different concentration of UEO revealed that the Seed viability and survival rates were higher for SAMMAZ 31 compared to SEEDCO 419, indicating a genetic basis for stress tolerance to UEO contamination. These findings corroborate stress physiology studies highlighting genotype-dependent seed resilience under chemical stress (Božena *et al.*, 2023; Shah *et al.*, 2021). The seed compromised percentage was notably higher in SEEDCO 419, reflecting increased susceptibility, a trend reported in other crop contamination assessments (Cechin *et al.*, 2023; Regreening Africa, 2020). Results of the vegetative growth parameters of SAMMAZ 31, and SEEDCO 419 under used Engine Oil contaminated Loamy soils revealed that vegetative growth including plant height, leaf number, fresh weight and dry weight declined as UEO concentration increased, demonstrating the phytotoxicity of UEO contamination (Ngozi *et al.*, 2017; Kawedo *et al.*, 2024). SAMMAZ 31 generally maintained superior growth metrics compared to SEEDCO 419 across contamination levels, suggesting better physiological tolerance possibly linked to root system robustness and cellular detoxification capacity (Azorji *et al.*, 2021; Robert *et al.*, 2025). However, The ANOVA analyses reveal that soil contamination with used engine oil significantly reduces maize plant height and leaf number, with oil concentration showing a very strong effect in both traits. Variety also influences these parameters significantly, with Variety A, showing better growth.

Fresh weight is moderately affected by oil concentration but not by variety, while dry weight shows no statistically significant response, suggesting it is comparatively less sensitive or requires more samples to detect differences. This implies used engine oil contamination markedly hinders aboveground growth and leaf development, critical for maize productivity. These findings corroborate the findings by Agbor *et al.*, (2024) conducted a detailed assessment of maize growth attributes on crude oil-polluted soils and the effects of bioremediation treatments. Their work showed that crude oil contamination significantly suppressed maize plant height, leaf area, leaf number, and overall growth performance. The study also documented significant varietal differences, with bio-remediated soils showing substantially improved growth parameters compared to untreated polluted soil. While in this study, it shows that there are strong contamination effects and varietal responses as revealed by ANOVA analyses on used engine oil contamination in maize growth. Soil nutrient analysis results shows that the UEO contamination led to elevated levels of heavy metals (Cu, Zn, Mn, Fe) exceeding agronomic safety thresholds, while essential macronutrients like Ca remained deficient. Excess potassium and sodium levels and higher UEO concentrations have adverse to plant growth (Asiamah *et al.*, 2021). These nutrient disruptions are consistent with reports associating hydrocarbon pollution with reduced soil fertility and micronutrient toxicity (Ikuesan *et al.*, 2019; Onwusiri *et al.*, 2017). Graphical data demonstrate significant negative correlations between increasing UEO concentrations and all measured growth parameters, reiterating the dose-dependent toxicity effect. SAMMAZ 31 consistently showed better retention of growth performance under stress, reinforcing its relative tolerance and suitability for cultivation on moderately contaminated soils (Yuting & Yuji, 2021; Ngala *et al.*, 2025). This suggests that varietal selection is key in managing productivity in polluted environments.

CONCLUSION

The study conclusively demonstrates that contamination of loamy soil with Used Engine Oil (UEO) detrimentally affects both seed germination and vegetative growth parameters in maize varieties SAMMAZ 31 and SEEDCO 419. Higher UEO concentrations severely reduce germination rates and seedling survival, with SAMMAZ 31 displaying greater resilience compared to SEEDCO 419.

Heavy metal accumulation and disruption of macronutrient balance in soil further exacerbate phytotoxic effects, inhibiting plant height, leaf number, and biomass accumulation. Despite no statistically significant differences in ANOVA tests for growth parameters across UEO levels, the consistent decline pattern and micronutrient toxicity concerns indicate significant agronomic risks from UEO contamination. Varietal differences suggest targeted cultivar selection can aid in managing polluted agricultural soils.

In line with findings of this study, it is recommended that cultivation on soils contaminated with high concentrations of Used Engine Oil should be avoided to prevent reduced crop productivity and potential heavy metal uptake in the food chain, a need to employ resistant or tolerant maize varieties such as SAMMAZ 31 when remediation is underway or contamination levels are moderate, to sustain crop production, regular monitoring of soil nutrient and heavy metal status should be implemented in contaminated fields using techniques like Atomic Absorbance Spectroscopy to guide fertilization and remediation interventions, soil decontamination strategies, including phytoremediation and soil amendments, should be develop to restore fertility and reduce toxic element bioavailability, proper disposal and management of Used Engine Oil should be encourage to mitigate environmental contamination and safeguard agricultural land and further research on molecular and physiological tolerance mechanisms in maize varieties should be carried out that can inform breeding programs aimed at improving resilience to soil pollutants.

CONFLICTS OF INTEREST

Authors declare no conflict of interest.

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