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Research Article
Effects of Spent Engine Oil on Germination and Early Seedling Establishment of Arable Crops

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Abstract
Background and Objective: Environmental pollution resulting from indiscriminate disposal of spent engine oil is an issue of global concern. This study was carried out in 2021 at the Biology Laboratory of the Federal University of Technology Owerri to investigate the effects of spent oil pollution on seed germination and early seedling establishment of *Vigna unguiculata* TGm-50, *Glycine max* and *Zea mays* TZm-30181. **Materials and Methods:** The seeds of each accession were placed in Petri dish lined with moist tissue paper at 0, 4, 8, 12 and 16% (v/v). The experiment was laid out in Complete Randomized Design (CRD) with three replicates. The effects of spent engine oil on the assayed parameters such as germination percentage, rate of germination, seedling root and shoot elongation, seedling dry and fresh weights of the seeds was determined. **Results:** The effects of spent engine oil on the assayed parameters such as germination percentage, rate of germination, seedling root and shoot elongation, seedling dry and fresh weights of the seeds were concentration and accession dependent. Seeds and seedlings of *Vigna unguiculata* TGm-50, *Glycine max* and *Zea mays* TZm-30181 grown at various treatment levels differed significantly ($p \leq 0.05$) from the control. Tolerance levels among the accessions were in the order: *Vigna unguiculata*> *Glycine max*> *Zea mays*. **Conclusion:** The used engine oil inhibited the germination and early seedlings growth of these crops in a dose dependent manner and those inhibitory effects of spent oil do not imply inhibition of subsequent growth. This study underscores the need to legislate against agricultural soil pollution with used engine oil.

Key words: Spent oil, *Vigna unguiculata*, *Glycine max*, *Zea mays*, pollution, seed, germination

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In most developing countries, mechanic workshops are sited in areas known as mechanic villages. These areas are officially designated for repairs and servicing of motor vehicles[1-3]. They are also used for other purposes such as recreational, residential and agricultural purposes[4]. Some of the wastes usually generated by automobile mechanics in these villages include but not limited to gasoline (petrol), diesel, spent engine oil and paints among others[5]. Unfortunately, these waste products are disposed indiscriminately by the artisans who know little about the resultant environmental harm[6-8].

Spent engine oil is known to contain a number of several different mixtures of chemical contaminants from engine wears such as heavy metals (lead, zinc, chromium, barium and arsenic) etc, polychlorinated biphenyls, lubricative additives, chlorodibenzofurans, decomposition products, aliphatic hydrocarbons etc.[9-12]. These contaminants get to the environment as a result of deliberate and accidental discharge/spill by motor and generator mechanics[13-14].

Previous authors have reported deleterious effects of spent engine oil soil contamination on the ecosystem. Studies by researchers[15-17] observed a significant decrease in soil properties subjected to various concentrations of spent engine oil. According to researchers[18-20], a significant decrease in height, number of leaves, leaf area and number of flowers, fruits and dry weight of *Solanum gilo* with increase in foliar spray of petroleum hydrocarbon. A study by Nwite and Alu[21], on the effects of spent engine oil on soil properties in an auto mechanic village revealed that the soil Pb values were predominantly acidic. Their study suggested a well-coordinated waste oil collection programme by the Government and concerned private sectors to minimize indiscriminate disposal of spent engine oil.

Barua *et al.*[22] reviewed an article on pollution in Nigerian auto mechanic villages and the findings revealed that environmental contamination is one of the major problems that plague the Nigerian auto mechanic villages. Their findings showed that 95% of the studied auto mechanic villages are located in the cities or nearby urban settlement.

According to Orji *et al.*[23] and Donkor *et al.*[24] engine oil affects the moisture content in *Corchorus olitorius* Linn. Nishitha *et al.*[25] and Echiegu *et al.*[26] reported a significant decrease in biochemical parameters including fiber and carbohydrate content in cowpea (*Vigna unguiculata*) growing in soil contaminated with spent engine oil. In *Zea mays*, leaf formation was disrupted, stunted growth and high mortality rate was observed when it was exposed to soils contaminated with used oil[27]. This resulted to low yield and poor quality of grains observed during harvest for *Zea mays* and *Arachis hypogea*[28]. This study was therefore carried out to investigate the effects of different levels of spent engine oil on germination and early seedling establishment using *Vigna unguiculata* TGm-50, *Glycine max* and *Zea mays* as the test crops.

MATERIALS AND METHODS

Study area: Investigations were carried out from March to June, 2021 in the screen house of the Department Biology, Federal University of Technology, Owerri located at latitude 5°23'11.76"N and longitude 6°59'29.76"E.

Collection and preparation of seeds: Seeds used in this study were collected from the gene bank of International Institute of Tropical Agriculture, Ibadan. The accessions are: TVu-13606 (*Vigna unguiculata* TGm-504 (*Glycine max*) and TZm-30181 (*Zea mays*). Seed viability test was carried by water floatation method following the method of Echiegu *et al.*[26]. The concentration was prepared by mixing appropriate volumes of distilled water to spent engine oil to obtain 0, 4, 8, 12 and 16% (v/v). Each concentration served as a treatment. Ten viable seeds of each accession were placed in 26 mm Petri dishes lined with cotton wool and moistened with the measured concentration of spent engine oil following the method of Anoliefo and Vwioko[27]. The seeds in each Petri dish were moistened with each level of contaminant and monitored for germination seedling growth for 14 days. The number of germinated seeds were recorded every morning at 9 am.

Experimental design: The experiment was laid out in completely randomized design with three replicates each. Seeds were considered as germinated when the root reached 2 mm long. Seeds that germinated from treatment were added cumulatively to obtain percentage germination. The reaction of the test plants to exposed contaminant at various concentrations was assessed in reference to control using phytotoxicity test parameters: Seed germination percentage and rate of germination, seedling root and shoot lengths after germination and recorded as follows:

$$\text{Percentage germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Rate of germination: The germination rate was determined as the coefficient of velocity of germination, as:

$$CVG = \frac{CV}{100} = \frac{1}{t}$$

where, t is mean germination time and CV is coefficient of velocity. In time, since the mean rate increases and decreases with 1/t not with t.

Seedling root and shoot elongation was measured with the aid a graduated meter rule (cm).

Seedling dry and fresh weights were determined using the method of Odjegba and Sadiq[28].

Statistical analysis: Data collected were subjected to Analysis of Variance (ANOVA) to analyze parameters assessed. The significant treatment means were separated using Duncan's Multiple Range Test (DMRT) at $\alpha \leq 0.05$ level.

RESULTS

Effects of spent engine oil on germination: Percentage seed germination of test plants (*Zea mays*, *G. max* and *V. unguiculata*) exposed to different concentrations of spent engine oil were presented in Fig. 1. Generally, more seeds germinated from 0% concentration than in the other treatments. It was observed that the percentage germination fluctuated among the accessions as follows: *Zea mays* (78%), *G. max* (71.6%) and *V. unguiculata* (89.4%), respectively. In 4% concentration, seeds of *V. unguiculata*, *Zea mays* and *G. max* more seeds emerged within 5 days of exposure in comparison with other treatments. More than 50% of the seeds of *V. unguiculata* emerged at 4% treatment level. Drastic reduction in germination percentage was observed at 8, 12 and 16% treatment when compared with seeds grown in control. There was a significant difference (p<0.05) in germination percentage among the test plants in the different treatments. The percentage germination of *G. max* at 8% treatment level was significantly lower relative to the control at 99.9% level of significance while the percentage germination of the seeds of *Zea mays* and *V. unguiculata* were significantly lower at a 99% significance level. At the 12% treatment level, seeds of *G. max* performed better with values of 39.5% compared with *V. unguiculata* (31.7%) and *Zea mays* (23.6%), respectively. The percentage germination of the seeds of *Zea mays* was significantly lower in 16% of treatments followed by *G. max* and *V. unguiculata* in that order. *Vigna unguiculata* showed strong tolerance to spent engine oil contamination with about 18.7% germination percentage at the highest concentration (16%) followed by *G. max* (17.8%) and *Zea mays* (15.2%).

Inhibitory effects of spent engine oil on *V. unguiculata, Zea mays* and *G. max*: The germination inhibition of maize at 0% was quite minimal with a value of 2.09% was shown in Fig. 2. However, when the concentration reached 8%, germination inhibition progressed to 57.7%. The 4% concentration did not inhibit the seed germination rate but slightly stimulated the germination rate as shown in Fig. 2. However, a rapid increase in inhibition was found between 12 and 16% concentration. The inhibition rate at 12% concentration was 88.5% which exceeded 50% indicating a significant effect on maize seedling establishment. The inhibition rate reached 89.8% at 16% concentration. No germination was observed inhibition was observed in 0% concentration in *V. unguiculata*. However, the rate of inhibition increased with elevated levels of spent engine oil concentration. The average inhibition rate was 48.9% at 8% concentration, not exceeding 50%, implying a strong tolerance of *V. unguiculata* to spent engine oil contamination. Generally, all concentrations had inhibitory effect on the germination rate with increasing concentration. A statistically significant inhibition rate was observed at 16% concentration, with a value of about 88.7% exceeding 50% at this level. Zero percent concentration resulted in no observable inhibition of germination in *Glycine max*. However, germination inhibition was observed with an increase in concentration. The rate of inhibition at 4% concentration was 37.9% suggesting mild tolerance of *Glycine max* to spent engine oil contamination. The highest inhibition rate was recorded in 16% concentration with a value of 87.9% which exceeded 50% at this level.

Effects of spent engine oil on early seedling establishment: The effect of spent engine oil treatments on early seedling establishment was presented in Table 1. The application of spent engine oil had a dose-dependent inhibitory effects on all the parameters assessed. Generally, the speed (rate) of germination from 0% was more vigorous than other treatments. The germination speed (rate) of *Zea mays* was generally more affected by all treatments than other species used in the bioassay. There was a significant difference (p<0.05) in the rate of germination in all the seedlings. There was a monotonic dose-dependent relationship in shoot length among the plants. However, 0% treatment level recorded the highest shoot length with mean values of 11.6±1.16 while the lowest mean value of 5.7±1.01 was observed at the 16%

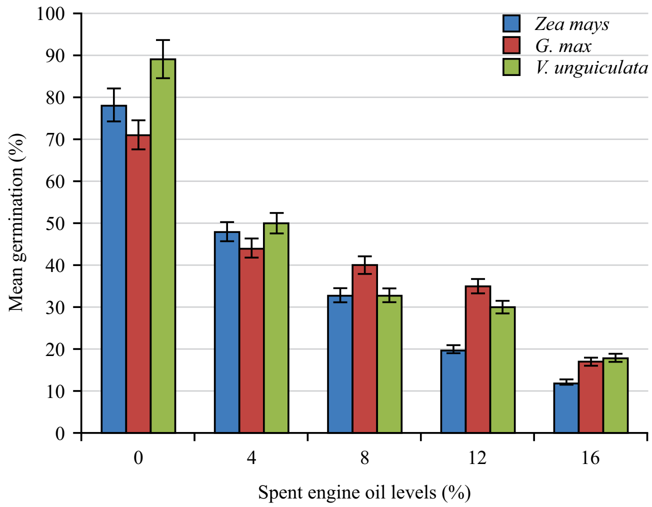

Fig. 1: Percentage seed germination *Zea mays*, *G. max* and *V. unguiculata* exposed to spent engine oil polluted and unpolluted soils

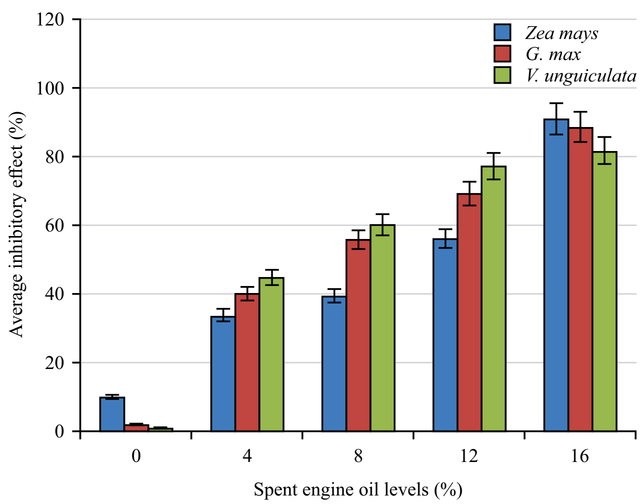

Fig. 2: Average inhibitory effects of plant species exposed to different concentrations of spent engine oil

Table 1: Germination rate, shoot and root length, seedling dry and fresh weights of test plants exposed to different concentrations of spent engine oil

Conc.(%)	Varieties	Germination rate	Shoot length (cm)	Root length (%)	Seedling fresh weight (kg)	Seedling dry rate weight (kg)
0	*Zea mays*	15±1.8[a]	11.6±1.16[a]	9.4±1.14[a]	7.7±1.09[a]	6.3±1.06[a]
4		14±1.24[a]	11.0±1.15[a]	8.1±1.11[a]	6.9±1.03[a]	5.8±0.84[a]
8		9±1.13[b]	8.5±1.13[b]	7.6±1.10[ab]	5.3±0.82[b]	5.6±0.71[a]
12		4±0.67[c]	7.4±1.07[b]	6.3±1.06[b]	4.9±0.72[b]	4.3±0.70[b]
16		3±0.41[c]	5.7±1.01[c]	3.5±0.43[c]	3.3±0.60[c]	2.9±0.44[c]
4	*G. max*	14±1.24[a]	13.5±1.12[a]	7.8±1.11[ab]	6.6±1.08[b]	5.1±0.69[a]
8		13±1.19[a]	11.8±1.17[a]	6.2±1.05[b]	5.8±1.02[b]	4.3±0.70[b]
12		10±1.14[b]	9.0±1.15[b]	5.4±0.84	5.1±0.79[b]	4.0±0.67[b]
16		5±0.73[c]	4.2±0.69[c]	4.1±0.68[c]	3.2±0.40[c]	23.0±0.02[c]
4	*V. unguiculata*	14±1.24[a]	12.7±0.03[d]	9.1±1.13[a]	6.6±1.9[b]	5.1±0.81[a]
8		12±1.17[b]	11.5±1.17[a]	8.3±1.11[a]	5.6±1.00[b]	4.3±0.70[b]
12		8±1.11[b]	9.3±1.16[b]	7.7±1.10[ab]	5.4±0.84[b]	4.0±0.67[b]
16		3±0.63[c]	4.1±0.68[c]	5.2±0.81[b]	3.2±0.59[c]	2.9±0.44[c]

Values are Mean+SD of triplicate samples, Mean along the column having different superscript of letters differ significantly at $p \leq 0.05$ level according to Duncan's Multiple Range Test (DMRT) treatment level for *Zea mays*. There was no significant difference ($p>0.05$) in shoot lengths between 0 and 4% treatments in for *Zea mays* and *G. max*. The overall mean shoot lengths in *Zea mays, G. max* and *V. unguiculata* were significantly different from each at $p<0.05$, respectively. The shoot lengths of the different plant species were significantly shorter in 4% treatment level than the control ($p<0.05$). Generally, there was a marked decrease in shoot length with a corresponding increase in treatments.

The mean root lengths of the different plant species were generally higher at 0% than other treatment levels. No significant difference ($p>0.05$) exists between the mean root lengths of *Zea mays* and *G. max* at 0 and 4% treatment levels. However, the root length of seedlings treated with 8% spent engine oil was longer than the roots of the seedlings of 12 and 16% contaminant levels, respectively. The root lengths of *V. unguiculata* were significantly higher at a 16% treatment level than *Z. mays* and *G. max* treated at a similar level. The seedling root lengths at 4, 8, 12 and 16% treatments were significantly shorter than the control treatment ($p<0.05$).

Seedling mean fresh and dry weights were affected by spent engine oil exposure in a concentration-dependent manner. The control recorded the highest mean seedling fresh and dry weights in all the test plants. No significant difference ($p>0.05$) was observed between 0 and 4% treatment among the test plants with respect to seedling fresh and dry weights. At 8 and 12% treatment levels, there was no significant difference ($p<0.05$) in mean seedling fresh weights in all the test plants. However, at 16% treatment level, a marked significant difference ($p>0.05$) was observed. Seedling dry weights followed a similar trend as the fresh weights. There was no significant difference ($p<0.05$) between mean seedling dry weights in *Zea mays* and *V. unguiculata.* Also, there is no significant difference ($p<0.05$) between seedlings dry weights for *G. max* at 8 and 12% treatment levels.

DISCUSSION

The results obtained from this study showed that used engine oil inhibited the germination and early seedling establishment of the test crops in a dose-dependent manner and those inhibitory effects of spent oil do not imply inhibition of subsequent growth. Previous authors have recorded phytotoxic effect on germination and early seedling establishment of crops grown in spent engine oil-contaminated soil[29,30]. The cessation of seed germination by spent engine oil observed in this study is in line with previous research reports by researchers[31-33], who opined that growth parameters in *Amaranthus hybridus* decreased as the concentration of crude oil contamination increased.

The toxic effect of spent engine oil used in this study was does-dependent. This finding is in agreement with the findings of Ikhajiagbe *et al.*[34] in which the inhibitory effect of spent engine oil on germination and seedling growth of *M. oleifera* was found to be dose dependent. Also, they are in congruent with the data presented for *Glycine max, Vigna unguiculata* and *Zea mays*[35]. It is possible that the embryo of the seeds could have been injured or killed if it comes in contact with the oil[36,37].

According to Kayode *et al.*[38], spent engine oil has the ability to prevent the uptake of nutrients, water and oxygen required for seed germination. This could be as a result of volatile fractions of oil which have the high wetting capacity and penetrating power, it enters the seed coat and kills the embryo. The presence of spent oil in the soil-plant micro-environment affects normal soil chemistry wherein nutrient release and uptake as well as the amount of water get reduced[39,40]. The result also showed tolerance of plant species in this order: *V. unguiculata*>*G. max*>*Zea mays*. Researchers had opined oil's effect on plants is species and variety dependent[41-43]. Training and awareness should be created to inform auto mechanics about the toxic nature of spent engine oil and possible environmental hazards. Given the level of sensitivities observed among the accessions used, *Zea mays*, *G. max* and *V. unguiculata* are recommended for biomonitoring of the ecosystem health. More studies should be carried out to ascertain the effect of spent engine oil pollution on the oxidative stress of the plants used in this study.

CONCLUSION

The effect of spent oil pollution on the Germination and Early Seedling Establishment of Arable Crops in the Tropics was investigated in this study. From the results obtained, it is evident that spent engine oil had significant effects on the test crops in a dose-dependent manner. It is thereby recommended that to reduce the loss of crops due to oil pollution in the tropics, plants should not be exposed to spent engine oil pollution when they are at the early stages of establishment. Also there should be stricter laws on indiscriminate disposal of spent oil in the environment, especially on farmlands as this could reduce the yield of crops affected by indiscriminate disposal of petroleum products pollution to the environment.

SIGNIFICANCE STATEMENT

This study was carried out to ascertain the phytotoxic effects of indiscriminate disposal of spent oil pollution on germination and early seedling establishment of arable crops in the tropics. Findings in this study showed that showed spent oil inhibited the germination and early seedling growth of these crops in a dose-dependent manner. The study further revealed that spent oil polluted-soils are unsuitable for germination and early seedling establishment of plants, hence there is a need to enlighten the artisans on the hazards of indiscriminate disposal of this pollutant into environmental media, especially soil. This will go a long way in ensuring human and environmental health, improved crop propagation and safety and food security in the tropics.

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