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Assessment of growth of *D. bulbifera* (L.) on contaminated soil (spent engine oil) and industrial effluent

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Abstract

Anthropogenic activities such as indiscriminate disposal of wastes have contributed immensely to environmental pollution and therefore hinder the existence of plants and other soil organism dwellers. The effect of soil contaminated with Spent Engine Oil (SEO) and Industrial Effluent (IE) soil on the growth and yield of Dioscorea bulbifera L. was investigated in the screen house. Four levels of concentrations: 0ml/15kg, 75ml/15kg, 225ml/15kg, 375ml/15kg of SEO and effluents from a Cocoa Industry were assessed. Growth of D. bulbifera were assessed by taking the following parameters; sprouting, plant height (cm), leaf area (cm), day of bulbil appearance (days), leaf length (cm), girth length (cm), and the number of leaves produced by D. bulbifera in each treatment. This study showed that SEO and IE in soil have highly significant ($P \leq 0.05$) effects on growth and yield of the plants. The germination time increased with increase in treatment concentration, with control having the shortest time of 28 days and 375ml/15kg concentration having longest time of 53 days. The growth of D. bulbifera was delayed as the levels of treatment were increased. The control was signfinicantly different ($P \leq 0.05$) from other levels of treatment, having highest height value of 576.67cm while IE had the lowest (179.08cm) at week 16. Control had the highest number of leaves (66.3) while IE had the lowest number (18.67). Likewise in leaf length, control had the highest length of 15.17cm while IE had lowest (9.07cm). In leaf area, control had the largest (141.69($x10^2$) cm^2) while the IE had the lowest (14.74($x10^2$) cm^2).

Keywords: Spent engine oil (SEO), industrial effluent (IE), *Dioscorea bulbifera* L., growth.

Introduction

Man depends so much on plants for survival either in term of food, medicine or raw materials. Apart from climatic and biotic factors that affect plant growth and yield, anthropogenic activities such as indiscriminate disposal of wastes, also hinders their survival. When soil is contaminated by wastes, it can hinder the protective function of plant, upset its metabolic activities, have a negative effect on its chemical characteristics and thereby reduce fertility and plant production[1]. Crude oil has been reported by many researchers that its presence in soil makes it unfavorable for plant growth by hindering the uptake of nutrients by plants[2]. The major concern about Spent Engine Oil (SEO) and effluents from industries is their release into the environment and this is becoming a significant threat that needs serious attention. Sources of SEO into the environment is not only from mechanic villages, but also from draining oil from automobile and generator engines[3].

Dioscorea bulbifera L. (air potato) is not a well know species of yam but it has an attribute to grow aggressively on variety of soil, weather and habitat[4]. In Nigeria, it is commonly referred to as, "Isu Eminna" (Yoruba), *D. bulbifera* is distinguished from all other species by having specialized aerial bulbils on the base of petioles. The medicinal benefit of the plant has been described and its potential in curing illness has been reported[5]. Hence, the objective of this study is to assess the Growth of *D. bulbifera* (L.) on contaminated soil (Spent Engine Oil) and Industrial Effluent.

Materials and methods

Collection and authentication of materials: Tubers of *D. bulbifera* were collected from a farm in Ote, Ilorin East Local Government Area, Kwara State, spent engine oil from mechanic village, Akure, Ondo State and the soil contaminated with effluent (cocoa waste products) from industry was collected from dump site of Cocoa Processing Company, Akure, Ondo State.

Experimental site: This study was carried out at the experimental site of Department of Biology, Federal University of Technology Akure, Ondo State. Located between latitudes 07^o16^I and 07^o18^IN and longitudes 05^009^I and 05^011^IE. This study was done during rainy season, the rainfall is about 1524mm per year and lasts for about eight months (March to October). It has mean annual relative humidity of about 80 per cent and atmospheric temperature range is between 28^oC and 31^oC.

Methodology: Each yam tuber (25g) was planted inside a plastic bucket (30cm deep), filled up to a height of 3/4 with a loamy soil and industrial effluent separately. The soil used was initially sterilized before the start of the experiment and spent engine oil was analysed for heavy metals. The treatment volumes of the spent engine oil that was mixed with the soil were 0ml/kg, 5ml/kg, 15ml/kg and 25ml/kg. All the treatments were replicated three times. The contaminated soil with industrial effluent and control without any treatment were also replicated three times. The spent engine oil was thouroughly mixed with the soil in plastic bucket contained 15kg of soil. The set up was allowed to stay for one (1) week for proper absorption of the spent engine oil. The bulbils of *D. bulbifera* L. were planted inside each treatment. The whole set up was kept inside a screen house, watering and taking were done and the plant was allowed to grow without applying fertilizer.

Assessment of Growth and yield of *D. bulbifera*: These were determined by recording the germination day, the plant height (cm), number of leaves, leaf length (cm), leaf area (cm^2), shoot length (cm) and day of bulbil appearance in each treatment. The growth of *D. bulbifera* in spent engine oil and industry polluted soil was compared with the *D. bulbifera* grown in the non contaminated soils. Leaf area determination was done by multiplying the length and breadth measurements of a leaf, multiplied by the number of leaves per plant and finally by a correction factor of 1.23 following the procedures of Agbogidi and Ejemete[6] and Agbogidi and Ofuoku[7].

Statistical analysis: Data taken were analyzed using analysis of variance (ANOVA) and means were separated using Duncan's New Multiple Range Test (DNMRT) at 5% level of significance using SPSS 21.0 software.

Results and discussion

Heavy metals in spent engine oil: Heavy metals such as iron, lead, zinc and copper were observed to be present in the Spent Engine Oil (SEO), with zinc having the highest quantity of 6.51mg/kg and lead of lowest amount of 0.21mg/kg as shown in Table-1.

Effect of contaminated soil on the sprouting of *D. bulbifera* planted: The germination period of *D. bulbifera* was increased by the presence of contaminant in the soil (SEO and IE) as shown in Figure-1. Plants in the control (0ml) experiment germinated after 28 days of planting but the germination time at the other treatment levels were delayed by 29%-93% as the concentration of SEO increased. The *D. bulbifera* planted on IE soil germinated after 39 days while those planted in 375ml SEO germinated after 53 days of planting.

Effect of contaminated soil on the height (cm) of *D. bulbifera*: Table-2 showed the height of *D. bulbifera* in contaminated soil over a period of time (weeks). For each week, control was significantly different ($P<0.05$) from other levels of SEO treatment and IE, having the highest plant height recorded, except in week 12 where control (251.0cm) was of no significant ($P>0.05$) from 75ml/15kg (141.03cm) and 225ml/15kg (151.80cm). Industrial Effluent had the least plant height recorded, but not significantly different from 75ml/15kg, 225ml/15kg and 335ml/15kg concentration. In week 14, IE (64.83cm) was significantly different from 75ml/15kg (222.33cm) and 225ml/15kg (215.03cm) but not significantly different from 375ml/15kg (180.03cm). Also, IE treated soil was significantly different from others in week 16 having the height of 179.08cm.

Effect of contaminated soil on the number of leaves of *D. bulbifera*: Control plants had significantly more leaves than in other treatment as shown in Table-3. At the end of the experiment the leaves number ranged from 18.67–66.3. No leaf was recorded for plants contaminated with 375ml/15kg and IE still from week 1 to 6.

Effect of contaminated soil on the leaf length of *D. bulbifera:* Table-4 shows that leaf length was affected by SEO and IE contamination in the soil, as control plants had the longest length in each week than other levels of treatment. Plant in the control was significantly higher ($p<0.05$) than other plants. In week 12, control was of no significant ($p>0.05$) from 75ml/15kg (11.03cm) and 225ml/15kg (9.97cm) but there was significant difference ($p<0.05$) among 75ml/15kg (11.03cm), 375ml/15kg (5.73cm) and IE (3.57cm).

Effect of contaminated soil on the leaf area of *D. bulbifera*: Leaf area of *D. bulbifera* was significantly reduced in soil contaminated with SEO and IE (Table-5). Control was significantly different from other level of treatments, with control having the highest leaf area and the least was recorded in IE. In week 12 and week 16, control was not significantly different from 75ml/15kg.

Effect of contaminated soil on the shoot girth (cm) of *D. bulbifera:* Table-6 showed the effects of contaminated soil on the shoot girth of *D. bulbifera* plant. For weeks 4 and 6, there was significant difference ($p<0.05$) between control and other levels of treatments. There was no significant difference ($p>0.05$) between control and 75ml/15kg from week 8 to 16, but control had the highest girth size (2.40cm, 2.67cm, 3.00cm, 3.20cm and 3.60cm for week 8 to 16 respectively) with the lowest girth in IE for each week, except in week 8. The study showed that in all the levels of treatment, plants in week 16 had the highest girth size.

Table-1: Heavy Metals in the Spent Engine Oil.

Heavy Metals	Value (mg/kg)
Iron	5.00
Lead	0.21
Zinc	6.51
Copper	1.03

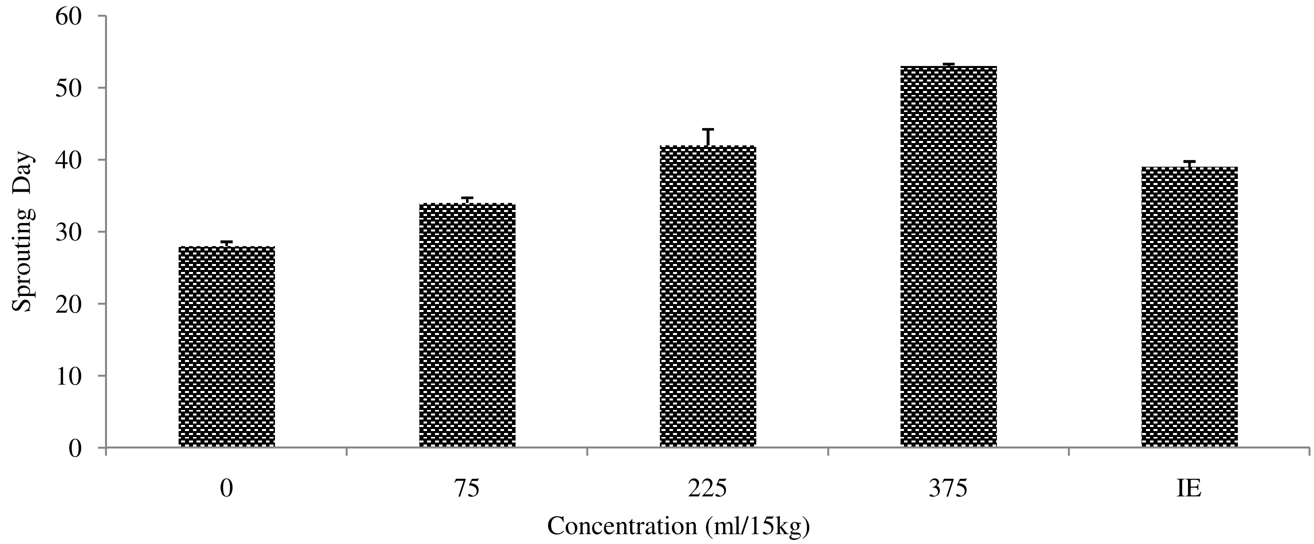

Figure-1: Sprouting of *Dioscorea bulbifera* planted at various concentrations of SEO and IE.

Table-2: Plant height (cm) of *D. bulbifera* grown in contaminated soil.

Concentration	Time (Weeks)							
	2	4	6	8	10	12	14	16
Control	39.33 ±12.70[a]	124.0 0±17.14[a]	172.00 ±22.17[a]	190.50 ±19.04[a]	208.67 ±23.77[a]	251.00 ±28.60[a]	377.03 ±31.36[a]	576.67 ±33.27[a]
A	5.00 ±1.10[b]	5.67 ±1.67[b]	23.33 ±4.52[b]	39.77 ±10.99[b]	69.40 ±11.42[b]	141.03 ±18.61[ab]	222.03 ±9.00[b]	342.33 ±15.32[b]
B	2.50 ±0.50[b]	3.83 ±0.83[b]	6.50 ±1.50[b]	10.67 ±3.36[b]	45.67 ±7.69[b]	151.80 ±7.69[ab]	215.03 ±5.77[b]	338.87 ±8.40[b]
C	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	17.17 ±8.79[b]	57.00 ±11.00[b]	180.03 ±10.35[bc]	313.03 ±8.43[b]
D	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	0.10 ±0.00[b]	12.50 ±2.04[b]	44.33 ±6.93[b]	64.83 ±4.76[c]	179.08 ±8.14[c]

Means ± standard error are not significantly different within a column if having the same alphabet, using Duncan's New Multiple Range Test (DNMRT) at P>0.05. A – 75ml/15kg of soil; B – 225ml/15kg of soil; C – 375ml/15kg of soil; D – Industrial effluent.

Table-3: Number of leaves of *D. bulbifera* grown in contaminated soil.

Concentration	Time (Weeks)							
	2	4	6	8	10	12	14	16
Control	6.30 ±2.18[a]	12.33 ±2.60[a]	17.00 ±2.13[a]	21.33 ±5.90[a]	24.67 ±5.93[a]	36.67 ±7.48[a]	54.67 ±4.87[a]	66.3 ±5.68[a]
A	1.30 ±1.33[b]	1.67 ±1.67[b]	3.33 ±1.33[b]	7.67 ±3.84[b]	15.67 ±3.38[ab]	32.67 ±3.84[ab]	54.67 ±2.40[ab]	54.7 ±4.49[a]
B	0.00 ±0.00[b]	0.67 ±0.67[b]	1.00 ±1.00[b]	1.67 ±0.88[b]	5.33 ±1.20[bc]	16.67 ±1.76[bc]	27.67 ±2.19[bc]	29.0 ±2.31[b]
C	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	3.33 ±1.40[c]	8.67 ±2.84[c]	20.00 ±1.73[cd]	31.0 ±3.20[b]
D	0.00 ±0.00[b]	0.00 ±0.00[b]	0.00 ±0.00[b]	1.33 ±1.33[b]	2.00 ±1.00[c]	4.00 ±2.08[c]	9.00 ±2.52[d]	18.67 ±1.76[b]

Means ± standard error are not significantly different within a column if having the same alphabet, using Duncan's New Multiple Range Test (DNMRT) at P>0.05. A – 75ml/15kg of soil; B – 225ml/15kg of soil; C – 375ml/15kg of soil; D – Industrial effluent.

Table-4: Leaf length (cm) of *D. bulbifera* plant grown in contaminated soil.

Concentration	Time (Weeks)						
	4	6	8	10	12	14	16
Control	9.33 ±1.28^{a}	10.00 ±1.04^{a}	10.47 ±2.95^{a}	11.67 ±2.06^{a}	13.37 ±1.31^{a}	14.75 ±0.82^{a}	15.17 ±0.60^{a}
A	1.00 ±1.00^{b}	1.70 ±1.70^{b}	4.10 ±1.92^{b}	6.97 ±1.89^{b}	11.03 ±0.62^{a}	12.21 ±0.40^{b}	12.65 ±0.32^{b}
B	0.93 ±0.93^{b}	0.97 ±0.97^{b}	1.30 ±0.85^{b}	4.47 ±0.66^{bc}	9.97 ±0.15^{ab}	10.86 ±0.66^{b}	12.16 ±0.51^{b}
C	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.00 ±0.00^{b}	2.17 ±1.11^{c}	5.73 ±2.41^{bc}	10.57 ±0.07^{b}	12.07 ±0.86^{b}
D	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.33 ±0.33^{b}	0.70 ±0.70^{c}	3.57 ±1.58^{c}	5.80 ±1.21^{c}	9.07 ±1.27^{c}

Means ± standard error are not significantly different within a column if having the same alphabet, using Duncan's New Multiple Range Test (DNMRT) at P>0.05. A – 75ml/15kg of soil; B – 225ml/15kg of soil; C – 375ml/15kg of soil; D – Industrial effluent.

Table 5: Leaf area (x $10^{2}cm^{2}$) of *D. bulbifera* grown in contaminated soil

Concentration	Time (Weeks)						
	4	6	8	10	12	14	16
Control	16.88 ±7.90^{a}	26.80 ±13.69^{a}	36.17 ±19.27^{a}	47.60 ±17.27^{a}	66.63 ±23.43^{a}	114.38 ±22.44^{a}	141.69 ±14.83^{a}
A	0.14 ±0.11^{b}	0.79 ±0.39^{b}	2.92 ±1.48^{b}	11.31 ±5.87^{b}	37.53 ±8.22^{ab}	55.19 ±3.76^{b}	111.53 ±8.05^{ab}
B	0.03 ±0.03^{b}	0.05 ±0.05^{b}	0.04 ±0.05^{b}	1.21 ±0.46^{b}	16.62 ±1.16^{b}	30.00 ±3.47^{bc}	42.29 ±0.65^{bc}
C	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.42 ±0.29^{b}	6.08 ±1.29^{b}	19.89 ±1.71^{bc}	43.43 ±5.03^{bc}
D	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.01 ±0.01^{b}	0.84 ±0.23^{b}	4.14 ±1.39^{c}	14.74 ±2.99^{c}

Means ± standard error are not significantly different within a column if having the same alphabet, using Duncan's New Multiple Range Test (DNMRT) at P>0.05. A – 75ml/15kg of soil; B – 225ml/15kg of soil; C – 375ml/15kg of soil; D – Industrial effluent.

Table-6: Shoot Girth (cm) of *D. bulbifera* plant grown in contaminated soil.

Concentration	Time (Weeks)						
	4	6	8	10	12	14	16
Control	2.10 ±0.06^{a}	2.13 ±0.09^{a}	2.40 ±0.12^{a}	2.67 ±0.24^{a}	3.00 ±0.25^{a}	3.20 ±0.46^{a}	3.60 ±0.51^{a}
A	0.53 ±0.53^{b}	0.60 ±0.60^{b}	1.77 ±0.15^{ab}	2.20 ±0.17^{ab}	2.30 ±0.10^{ab}	2.37 ±0.12^{ab}	2.43 ±0.13^{ab}
B	0.47 ±0.47^{b}	0.50 ±0.50^{b}	1.10 ±0.56^{bc}	1.87 ±0.13^{abc}	1.97 ±0.13^{b}	2.20 ±0.10^{ab}	2.20 ±0.06^{ab}
C	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.00 ±0.00^{c}	1.17 ±0.58^{bc}	1.87 ±0.09^{b}	1.90 ±0.12^{ab}	2.20 ±0.06^{ab}
D	0.00 ±0.00^{b}	0.00 ±0.00^{b}	0.63 ±0.63^{bc}	0.63 ±0.63^{c}	0.83 ±0.44^{c}	1.47 ±0.18^{b}	1.70 ±0.15^{b}

Means ± standard error are not significantly different within a column if having the same alphabet, using Duncan's New Multiple Range Test (DNMRT) at P>0.05.

Discussion: Generally from this study, all the growth parameters; germination day, plant height, number of leaves, leaf length, leaf area, girth length, and day of bulbils emergence were significantly affected by contamination of soil by spent engine oil and industrial effluent. This is in agreement with the findings of some researchers on effects of spent engine oil on some plants[8-10]. In Nigeria, especially in the rural area where majority of their activities is on agriculture, soil are easily contaminated with different types of waste and this has negative effects on the growth and yield of plant crops. Without any doubt, industrial effluents also impair soil productivity and have negative impact on crop production[11]. The findings show marked differences in the growth parameters between the plant on non contaminated soil and contaminated soil (spent engine oil and industrial effluents).

The presence of contaminants in the soil significantly prolonged the normal duration for *D. bulbifera* to sprout. Days of germination were delayed in all the levels of contamination with SEO and IE when compared to the control. Delay in germination time may be due to SEO's physical water repellent property that interfered with the seed accessibility to water necessary for its growth. The tuber will then be surrounded with contaminants, thereby injuring or killing the plant. This effect was also observed by Adam and Duncan[12] that petroleum contaminants reduced the germination rate of commercial crops. Lale *et al.*[13] also reported that oil contaminated soil caused delay in seed emergence but it depend on plant species and amount of oil. The soil effluent from cocoa industry excessively retained water (poorly drained), therefore affecting the viability of the tuber planted. Factory effluents were found to be deleterious for early germination and performance in plants[14].

Reduced plant heights, number of leaves, leaf length and leaf area of plants exposed to oil treatments and effluents have been reported also by many researchers. Benka-Coker and Ekundayo[15] observed that the reduction may be due to soil conditions that was not favourable as a result of inadequate aeration, air filled pore space been decreased and effect on soil microbes. Siddiqui and Adams[16] stated that the presence of herbicidal properties of the oil can also affect the growth of a plant. Also, Agbogidi and Egbuchua[17] noted that contaminants lowered biochemical and metabolic processes of a plant as well as disruption in the soil water-plant interrelationship. This research concurs with Jung[18] who found that leaves number decreased as pollution level increased. Uaboi-Egbenni *et al.*[19] worked on the effect of industrial effluents on a selected plant and found that the mean leaf length obtained was higher for the control and the leaf length was more affected by the effluents.

No significant difference in the stem girth starting from week 10 upward in contaminated soils when compared with the control. This was evidenced that after a long period of time, *D. bulbifera* became tolerant to SEO and IE. The same observation was made by Okonokhua *et al.*[20] and Adu *et al.*[21], in which at all concentration levels used, maize stem girth has no significant differences. Though, it was reported that girth values decrease as the concentration increased. Ammar *et al.*[22] found out from his findings that industrial effluent had positive effect on plant stem girth.

Industrial effluent drastically reduced the plant height when compared with spent engine oil contamination and this may be due to the fact that the IE contained small percent of sand, silt and clay which have necessary nutrients and soil microorganisms for proper growth of the plants.

Conclusion

This work has revealed that spent engine oil and industrial effluent pollution on soil has an adverse effect on growth and yield of air potato (*Dioscorea bulbifera*). Soil contamination could cause food scarcity and loss of biodiversity. There should be enforcement of law by the government to regulate the disposal of spent engine oil and the industrial effluent in the environment. Public awareness should also be intensified on the effects of soil pollution to the environment.

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