Ethiopian Journal of Environmental Studies & Management 8(Suppl. 2): 906 – 915, 2015.
ISSN:1998-0507 doi: http://dx.doi.org/10.4314/ejesm.v8i2.5S
Submitted: May 19, 2015 Accepted: November 05, 2015

PHYTOTOXICITY EFFECT OF SPENT OIL ON *Jatropha curcas* SEEDLINGS USED IN SOIL PHYTOREMEDIATION

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Abstract

Soil contamination by Spent Lubricating Oil (SLO) is a growing concern in many African countries including Nigeria. Phytoremediation is an environmentally friendly and cost-effective approach that is used in restoring such soils. This study employed Jatropha curcas seedlings in phytoremediating organically amended and unamended soil contaminated with 0, 3 and 6% (w/w) SLO for 84 days. The possible effects of the polluted soil on the growing seedlings were investigated through a fortnight assessment of height growth, leaf production and stem diameter. The results showed significant differences (P<0.05) in height, stem diameter and leaf production across the 0 (control), 3 and 6% levels of pollution on amended and unamended soil types investigated. The values recorded for growth parameters were dose dependent. At the end of twelve weeks, 0% pollution level recorded the highest mean height (56.15cm), mean stem diameter (7.42cm) and mean number of leaves (49.28). The mean height for 3% pollution level was 22.34cm while mean diameter and mean leaf number were 3.86cm and 10.23 respectively. Lowest values of mean height (15.83cm), mean stem diameter (2.81cm) and mean number of leaves (5.73) were obtained at 6% level of pollution. For amended soil, higher values of mean height (43.04cm), mean stem diameter (5.66cm) and mean number of leaves (34.96) were obtained as against mean values of 19.84cm, 3.74cm and 8.54 of height, stem diameter and number of leaves for unamended soil. Although spent oil concentration had negative effect on the growth parameters investigated, it did not interfere with the phytoremediating process.

Key Words: *Phytoremediation, Jatropha curcas, SLO, pollution*

Introduction

The soil is an important component of the environment. It plays very significant roles as an abiotic component of the ecosystem by serving as the main medium of growth for plants and home to a large number of micro and macro organisms including bacteria, viruses, insects and worms (Adesodun and Nbagwu, 2008). The state of the soil is very important as it determines the quantity and quality of produce from it. According to Agamuthu *et al.* (2010) a fertile soil possessing all the essential nutrients for plant growth and with negligible contaminants will produce food materials with little or no detrimental effect on man and other animals. The global emphasis on soil health and sustainable food security is persuading soil scientists and toxicologists to consider rehabilitation of degraded lands especially

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where oil contamination is involved (Nwoko, 2010).

Crude oil pollution is the most common form of oil based soil pollution. However, crude oil spills are often localized. In Nigeria, for example, most oil spill incidences occur in the Niger Delta area and directly affect the inhabitants of the communities involved. Another important oil-based soil pollutant is spent lubricant. The spent lubricant, otherwise called waste engine oil, spent engine oil or spent lubricating oil (SLO)) is usually obtained after servicing and subsequently draining lubricating oil from automobile and electric generator engines.

Pollution from SLO is an environmental problem which is more widespread than crude oil pollution (Odjegba and Sadiq, 2002).This is because SLO from automobiles, generators and other machines is indiscriminately dumped into the environment across the length and breadth of the country. Adegoroye (1997) reported that in Nigeria and some developing countries about 80 million litres of waste engine oil is generated annually from mechanic workshops and discharged indiscriminately into the environment. This renders the environment unsightly and constitutes a potential threat to humans, animals and vegetation (Adelowo *et al.,* 2006).

Phytoremediation is an innovative technology that uses plants to remove environmental contaminants such as heavy metals and organic compounds (White *et al.,* 2006; Jilani and Khan, 2006). It is a novel plant-based remediation technology applied to inorganic and organic contaminated soils, water and sediments all over the world which makes use of naturally occurring processes by which plants and their microbial rhizosphere fauna degrade and sequester organic and inorganic pollutants (Pradhan *et al.,* 1998).

Jatropha curcas has been reported to be very useful in removing pollutants from the soil. For example, it is known to have been used on heavy metal polluted soils especially hexavalent chromium, in some countries of the world (Mangkoedihardjo *et al.*, 2008). The increasing interest in *Jatropha curcas* for phytoremediation could be due to its high resistance and ability to thrive well in adverse conditions. It is also reported to be well adapted to acid and moisture demands and grow well on wasteland. This potential use of the species has made it imperative to carry out an investigation on its potential in the phytoremediation of spent oil polluted soil. (Agamuthu *et al.,* 2010; Abioye *et al.,* 2012; Chang *et al.,* 2014).

Methodology

Study Area

The experiment was carried out at the Nursery Site of the Moist Forest Research Station (6° 32′N 5° 58′E), Forestry Research Institute of Nigeria (FRIN) Benin City, Edo State, Nigeria.

Soil Sampling

Top soil (0 – 15cm) was collected from the Forest Floor of Acacia Plantation of the Research Station. The soil was thoroughly mixed and passed through a 2mm sieve to remove the non-soil particulate. The chemical and physical properties of the soil including Heavy Metal Analysis were determined prior to introduction of the *J. curcas*. Contamination was done at 3 levels (0%, 3% and 6% w/w) of spent oil in 6kg top soil and two classes of soil were used based on amendment with organic manure (amended and unamended soils). In both cases, the soil was thoroughly homogenized.

Soil Preparation and Planting

Six kilogramme (6kg) polythene pots were utilized for the experiment. Experimental Design was 2 x 3 Factorial in a Completely Randomized Design and replicated 3 times. The first factor was soil amendment (amended and unamended soil) and the second factor was three levels of spent oil pollution (0%, 3% and 6% weight by weight (w/w)). Ten seedlings were used for each level of pollution, translating to 30 seedlings per replicate and a total of 180 seedlings (90 seedlings for amended soil and 90 seedlings for unamended soil) for the experimental setup.

The pots were filled with topsoil, thoroughly mixed for even distribution of introduced organic manure (10% w/w) and spent oil contaminants and watered to field capacity. Earlier raised seedlings of *J. curcas* were transplanted to the polluted soils at 3 weeks after planting.

Based on the setup, the treatment combinations used in this study were:

Unamended (w/w)
0% level of contamination
6kg topsoil+0 kg spent lubricating oil (NP_0)
3% level of contamination
6kg topsoil + 0.18kg of spent lubricating oil (NP_3)
6% level of contamination
6kg topsoil+ 0.36kg of spent lubricating oil (NP_6)
Amended (w/w)
0% level of contamination
6kg topsoil+0 kg spent lubricating oil + 0.6 kg Organic Manure (AP_0)
3% level of contamination
6kg topsoil+ 0.18kg of spent lubricating oil + 0.6 kg Organic Manure (AP_3)
6% level of contamination
6kg topsoil+ 0.36kg of spent lubricating oil + 0.6 kg Organic Manure (AP_6)

Data Collection

Growth parameters such as plant height, number of leaves and stem diameter were measured using metre rule, visual count and venier calliper respectively starting from four weeks after planting (WAP) at two weeks interval for twelve weeks. This was done on five randomly selected seedlings from each treatment class (level of pollution).

Results

Table 1: Physicochemical Properties of Soil and Organic Manure used for Phytoremediation

PARAMETERS (%)	ORGANIC MANURE	NP_0
Organic Carbon	36.38	0.93
Sand	6.26	91.84
Silt	0.00	4.67
Clay	0.00	3.49
pH	5.78	6.85
Nitrogen (N)	2.13	0.12
Calcium (Ca)	1.18	0.008
Magnesium (Mg)	0.67	0.003
Potassium (K)	1.03	0.011
Sodium (Na)	0.49	0.006

N - Unamended Soil
P_0 - 0% Pollution Level

Table 2: Effects of Pollution Levels and Soil Amendment on Mean Heights of *J. curcas* Seedlings used in Phytoremediation

Treatments	Height (cm)					
	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
Soil Amendment						
AS	14.54a	17.55a	22.18a	30.24a	37.35a	43.04a
NAS	11.98b	13.03b	13.97b	15.96b	17.80b	19.84b
SE±	0.21	0.41	0.45	0.70	0.78	1.31
Pollution Levels						
0	15.36a	19.26a	26.01a	36.27a	46.45a	56.15a
3	12.53b	13.54b	14.59b	18.85b	21.07b	22.34b
6	11.90b	13.11b	13.63b	14.19c	15.20c	15.83c
SE±	0.26	0.51	0.55	0.86	0.96	1.60

Values are means ± S.E
Means with the same alphabets are not significantly different at 5% level of significance using DMRT
WAT – Weeks after Transplanting
AS – Amended Soil
NAS – Unamended Soil

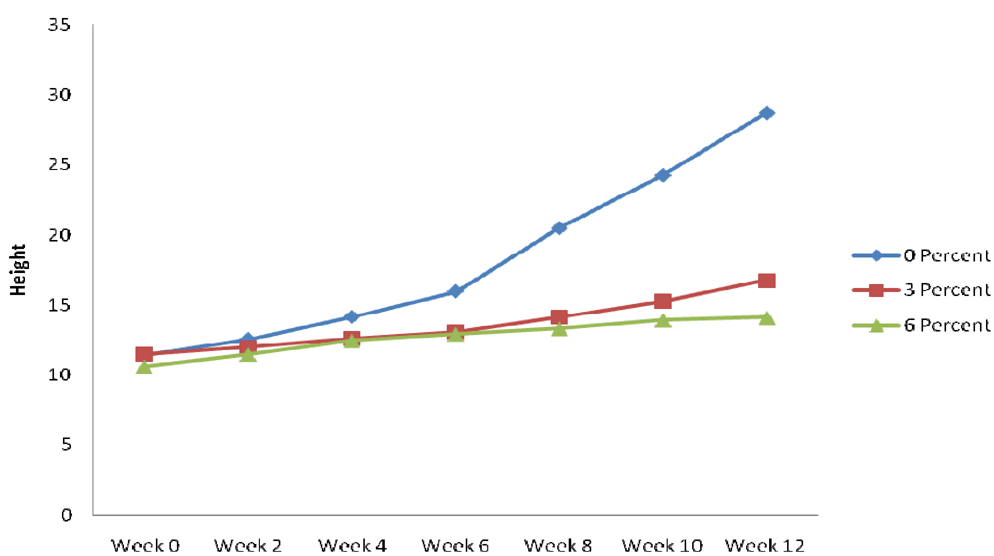

Figure 1: Plant height of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in amended FRIN Soil

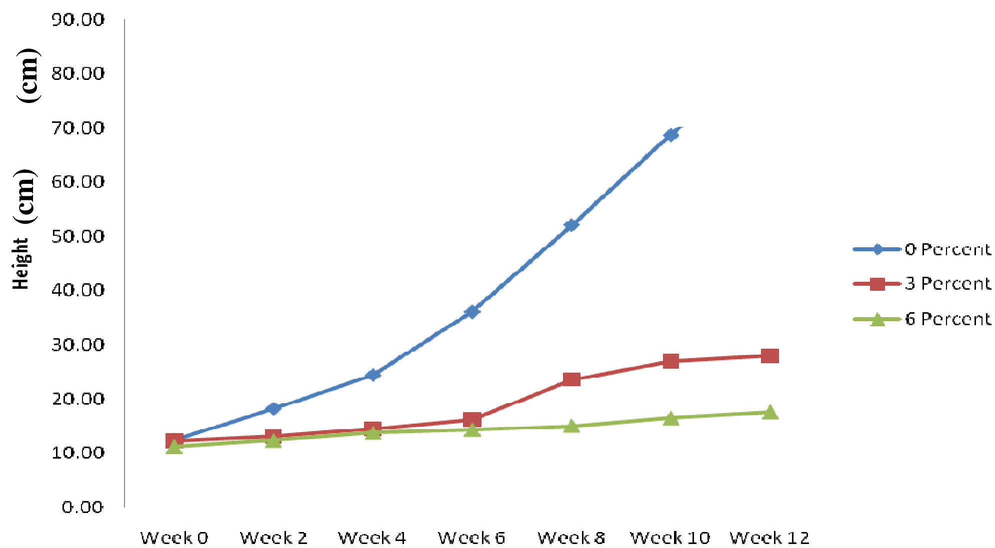

Figure 2: Plant height of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in unamended FRIN Soil

TABLE 3: Effects of Pollution Levels and Soil Amendment on Stem Diameter of *J. curcas* Seedlings

Treatments	Stem Diameter (cm)					
	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
Soil Types						
AS	2.27a	2.63a	3.68a	4.31	4.85a	5.66a
NAS	2.10b	2.33b	2.86b	3.09	3.25b	3.74b
SE±	0.21	0.048	0.05	0.07	0.11	0.11
Pollution Levels						
0	2.65a	3.14a	4.60a	5.43a	6.05a	7.42a
3	1.96b	2.19b	2.74b	3.13b	3.47b	3.86b
6	1.95b	2.11b	2.46c	2.54c	2.62c	2.81c
SE±	0.03	0.58	0.06	0.08	0.14	0.13

Values are means ± S.E
Means with the same alphabets are not significantly different at 5% level of significance using DMRT
WAT – Weeks after Transplanting
AS – Amended Soil
NAS – Unamended Soil

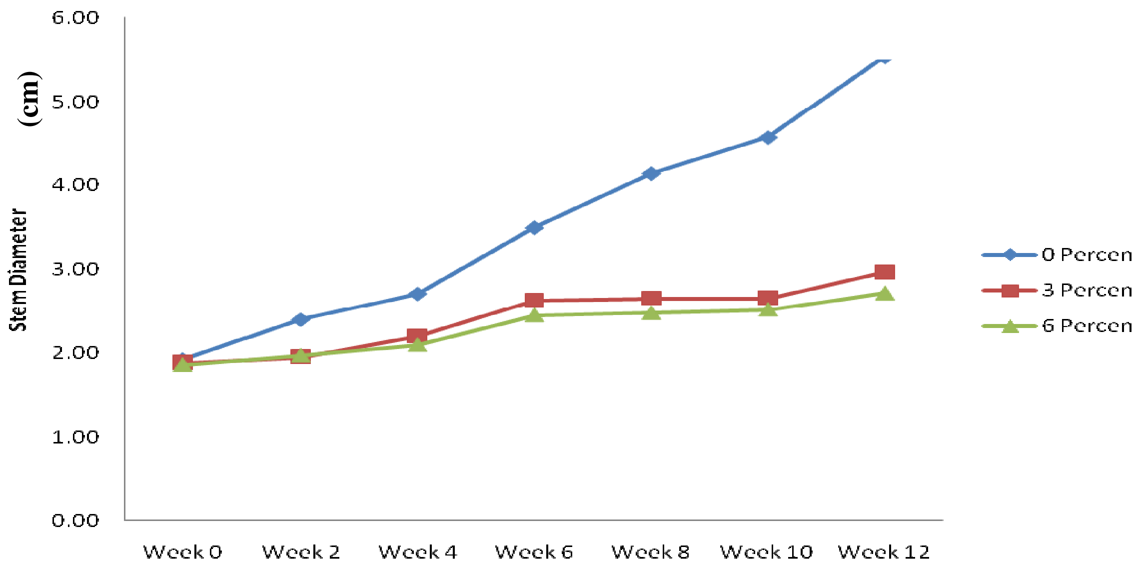

Figure 3: Stem Diameter of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in unamended FRIN Soil

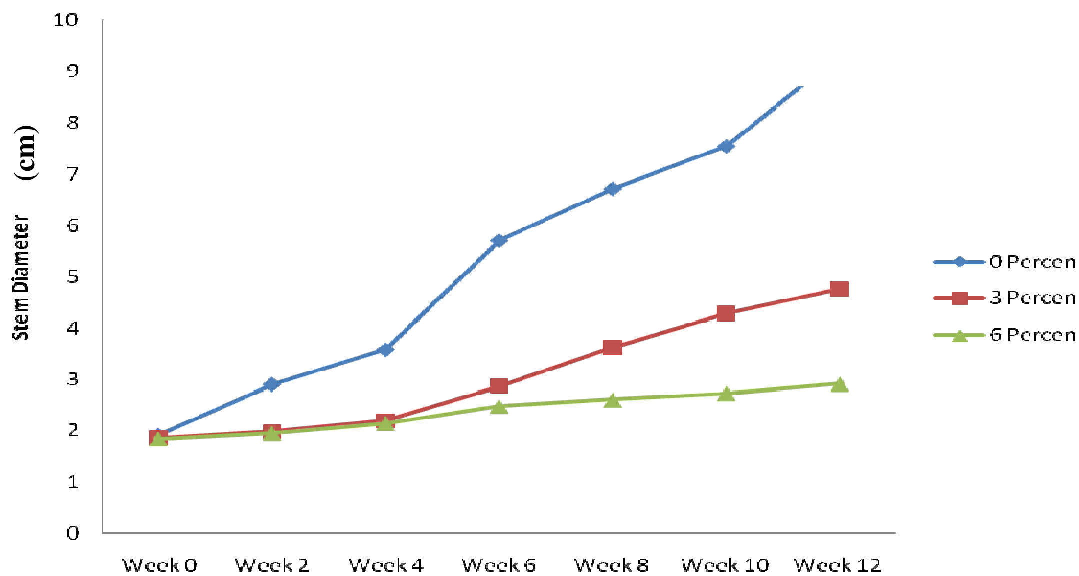

Figure 4: Stem diameter of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in amended FRIN Soil

Table 4: Effects of Pollution Levels and Soil Amendment on Mean Number of Leaves of *J. curcas* Seedlings

Treatments	Number of Leaves					
	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
Soil Amendment						
AS	5.40a	8.80a	19.09a	28.03a	30.12a	34.96a
NAS	4.90b	5.29b	6.22b	6.68b	7.69b	8.54b
SE±	0.15	0.43	0.52	3.87	0.99	0.45
Pollution Levels						
0	7.83a	11.87a	26.93a	31.67a	41.97a	49.28a
3	4.00b	4.87b	6.17b	15.55b	9.67b	10.23b
6	3.63b	4.40b	4.87c	4.85c	5.08c	5.73c
SE±	0.19	0.53	0.63	4.74	1.21	5.73

Values are means ± S.E
Means with the same alphabets are not significantly different at 5% level of significance using DMRT
WAT – Weeks after Transplanting
AS – Amended Soil
NAS – Unamended Soil

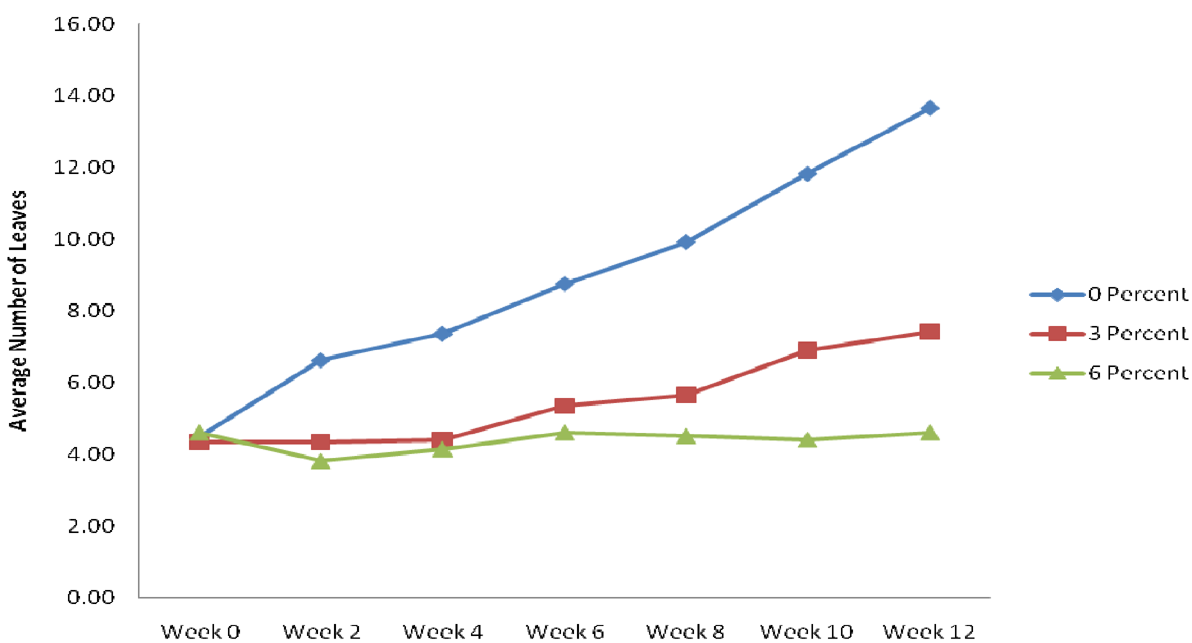

Figure 5: Number of Leaves of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in unamended FRIN Soil

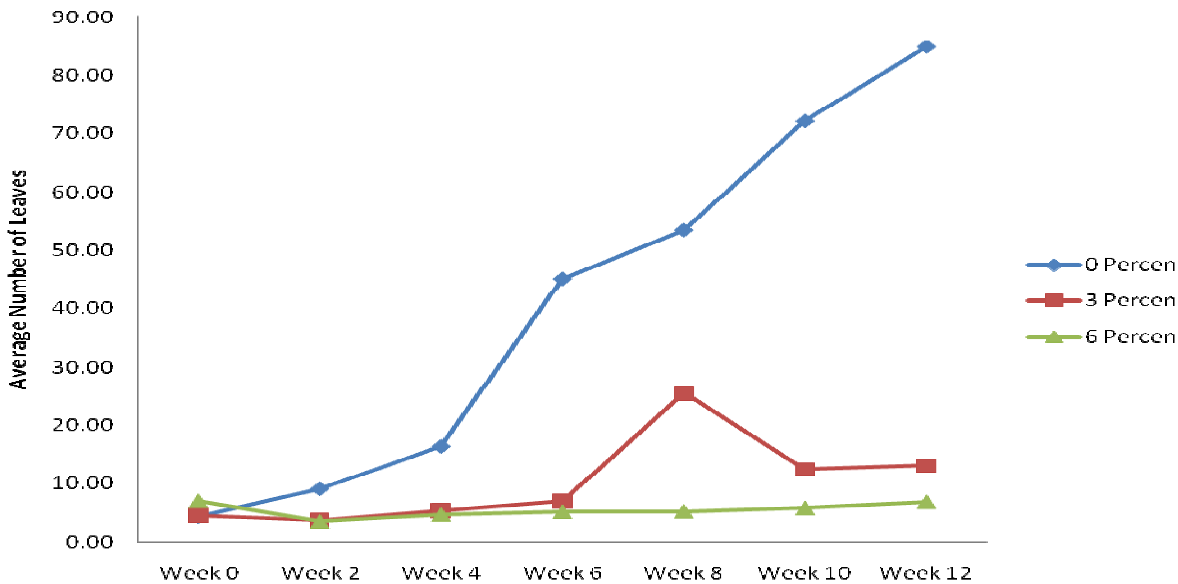

Figure 6: Number of Leaves of *Jatropha curcas* as affected by Spent Lubricating Oil (SLO) concentration in amended FRIN Soil

The tables and figures above summarize the observable growth variations during the experiment. At the end of twelve weeks, 0% pollution level recorded the highest mean height (56.15cm), mean stem diameter (7.42cm) and mean number of leaves (49.28). The mean height for 3% pollution level was 22.34cm while mean diameter and mean leaf number were 3.86cm and 10.23 respectively. Lowest values of mean height (15.83cm), mean stem diameter (2.81cm) and mean number of leaves (5.73) were obtained at 6% level of pollution. For amended soil, higher values of mean height (43.04cm), mean stem diameter (5.66cm) and mean number of leaves (34.96) were obtained as against mean values of 19.84cm, 3.74cm and 8.54 of height, stem diameter and number of leaves for unamended soil.

The results showed significant differences ($P<0.05$) in height, stem diameter and leaf production across the 0 (control), 3 and 6% levels of pollution on amended and unamended soil types investigated (Tables 2, 3 and 4 respectively).

Discussion and Conclusion

A summary of the observations on growth parameters shows that soil amendment resulted in better performance in terms of mean height, mean stem diameter and mean number of leaves. On the other hand, increased contamination of soil with SLO (3 and 6% levels of contamination) had observable adverse effects on the growth parameters. This observation is in conformity with Odjegba and Sadiq (2002) who examined effects of spent engine oil on the growth of *Amaranthus hybridus* and reported that the mean height of the control was significantly greater than those of plants grown on soil treated with 1-5% spent engine oil. This was corroborated by Vwioko and Fashemi (2005) who investigated growth response of five different plant species in soil supplemented with spent lubricating oil at 1-6 % w/w strengths and concluded that the growth parameters demonstrated an overall dose dependent response. Sharifi *et al.,* (2007) also alluded to the fact that spent oil has detrimental effects on germination rate and above ground height of plants. They stated that the various responses of plant species to spent oil contaminant appear to be dose dependent.

The reduction in plant growth parameters may be due to the effects of aliphatic, aromatic and phenolic compounds that reduce respiration, transpiration and photosynthesis as well as systemic toxic effect of translocation of long chain alkanes to stems (Trap *et al*., 2005). Molina-Barahona *et al*., (2005) inferred that it could also be due to the impermeability effect of the fuel, the immobilization of nutrients mainly nitrogen and by inhibitory effects of some of the polycyclic aromatic hydrocarbon components. Various studies have shown that the dynamics of solubilization and ionic exchange in soils have been negatively affected under the influence of Spent Lubricating Oil (Odjegba and Sadiq, 2002).

In conclusion, this study has been able to show that;

- *J. curcas* seedlings can survive on SLO contaminated soil of 0, 3 and 6% contamination levels as a phytoremediator.
- Negative effect of SLO on growth parameters such as height, stem diameter and number of leaves is dose dependent. The dose dependent effect on growth parameters did not interfere with the phytoremediating function of the species at the level of pollution investigated.

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