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Research Paper

GROWTH RESPONSE OF *Jatropha curcas* (LINN.) SEEDLINGS GROWN IN SPENT ENGINE OIL CONTAMINATED SOIL

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Abstract: This study was conducted at the research farm of Department of Forestry and Wildlife, Delta State University Asaba campus, Delta State, Nigeria to evaluate the effects of spent engine oil contaminated soil on the growth parameters of *Jatropha curcas* seedlings. The levels of oil used were 0.00, 3.45, 6.92, 10.39 and 13.86 (%w/w). The results showed that the performance of seedlings grown in the contaminated soil in terms of plant height number of leaves, leaf area and collar diameter when compared with seedlings in control were significantly ($p \leq 0.05$) reduced. For example at four weeks after transplanting (WAT), plant height, leaf area, number of leaves and collar diameter had the values of 13.27cm, 4.67, 67.72cm², and 2.43 in control as against 10.27cm, 2.33, 12.56cm² and 1.99 in soil contaminated with 13.86(%w/W) level of oil respectively, while at 12 WAT, plant height, number of leaves, leaf area and collar diameter had 15.60cm, 7.40, 102.65cm², and 3.87 in control against 10.87cm, 1.80, 9.10cm² and 2.11 in 13.86(%w/w) level of oil respectively. The reductions observed in the parameters were spent engine oil concentration dependent. No death was recorded indicating that the plant tolerated all the levels of spent oil used, although, the rate of tolerance decreased as the levels of oil increased. Thus study has shown that 3.45 (%w/w) level of the oil present in a soil is the critical level for *Jatropha curcas*, above which significant reduction in growth parameters of *Jatropha curcas* was recorded.

Key words: spent engine oil, *Jatropha curcas*, contamination, soil.

Introduction

Jatropha curcas L. (physic nut) is a species of flowering plant in the spurge family Euphorbiaceae, which is native to the American tropics most likely Mexico and Central America (Janick and Robert, 2008). It is cultivated in tropical and sub – tropical regions around the world becoming naturalized in some areas. The specific name “curcas” was first used by a Portuguese doctor Garcia de orta, more than 4,000 years ago and is of uncertain origin. Their common name includes Barbados nut, purging nut, physic nut or JCL (Sukarin *et al.*, 1987). *Jatropha curcas* is a poisonous semi-evergreen shrub or small tree reaching a height of 6m i.e. (20 feet) with a smooth grey bark (Agbogidi *et al.*, 2011a; Agbogidi *et al.*, 2012). The leaves are large and usually pale green. The plant produces flowers and fruits throughout the year, the fruit contains 37.5% shell and 62.5% seed (Singh *et al.*, 2007) seed are said to resemble castor in seed shape and black in colour, they have 42% husk and 58% kernel (Singh *et al.*, 2007). The seeds are encased within green capsule in the plant’s fruits. Seeds are matured when the capsule changes from green to yellow.

Jatropha curcas can be grown from either seeds or cuttings, for plants started as seeds germination is achieved within 9 days and yielding begins between 9 and 12 months. The seed become matured when the capsule changes from green to yellow, after two to four months. The seed is black and in the average 18mm long (11-30) and 10mm wide (7-11) (Henning, 2008). The seed contains 27 – 40% oil (average of 34.4%) that can be processed to produce a high quality biodiesel fuel usable in a stand diesel engine (Achten *et al.*, 2008). It is traditionally used as hedging plants in part of India to protect Agriculture and livestock. It was used in some areas in Africa as a grave marker. *Jatropha curcas* as biodiesel tree and countries like Nigeria to reducing emission from fossil fuel and reduce deforestation, improving energy efficiency and transforming urban transport. Such an approach can simultaneously support economic recovery and encourages growth in areas that mitigate the impact of climate change. The rapid development of the global biodiesel industries has been closely observed by countries that are interested in stimulating economic growth, improving the environment and reducing dependency on imported oil. Developing biofuel represent the most immediate and available response to four key challenges and opportunities.

The seeds have been used as insecticides (Adebowale and Adedire, 2006; Ampitan *et al.*, 2011) once de-shelled the glycerin with the almond of the seed can be used to make soap, the pressed cakes that remains after oil has been extracted are often used as organic fertilizer because of their high concentration of Nitrogen. The wood and the seed cake both can be used as fire wood or charcoal (Kumar *et al.*, 2008). Spent engine oil, which is also known as used mineral based crankcase oil, is a brown to black liquid produced when new mineral–base crankcase oil is subjected to high temperature and high mechanical strain, Agency for Toxic Substances and Disease Registry (ATSDR, 1997). spent engine oil is a mixture of several different chemicals (Wang *et al.*, 2000) including low and high molecular weight (C₁₅ – C₂₀) aliphatic hydrocarbons, aromatic hydrocarbons, polychlorinated biphenyls, chlorodibenzofurans, lubricating additives, decomposition products, heavy metal contaminants such as aluminum, chromium, tin, lead, manganese, nickel and silicon that comes from engine parts as they wear down (ATSDR, 1997). Spent engine oil is a common and toxic environmental contaminant not naturally found in the environment (Dominguez *et al.*, 2004). Large amount of spent engine oil are liberated into the

environment when the motor oil is changed and disposed into gutters, water drains, open vacant plots and farm lands, a common practice by motor mechanics and generator mechanics (Odjegba and Sadiq, 2002). In addition, the oil is also released into the environment from the exhaust system during engine use and due to engine leaks, (Anoliefo and Edegbai, 2000). Spent engine oil, when present in the soil, creates an unsatisfactory condition for life in the soil which is due to the poor aeration it causes in the soil, immobilization of soil nutrients and lowering of soil pH (Atuanya, 1987). Soil enzymes are biologically produced substance which bind with substrate in stereoscopic position that causes changes in the electronic configuration around certain susceptible bonds that culminates in biochemical reactions (Zahir *et al.*, 2001). The activities of soil enzymes provide an integrated measure of the biological status of the soil (Li *et al.*, 2005).

Spent lubricating oil (waste engine oil), has been reported as one of the major and most common soil contaminants (Anoliefo and Edegbai, 2000). The spent lubricating oil is usually obtained after servicing and subsequently draining used oil from automobiles and generator engines, the disposal of spent oil into gutters, water drains, open vacant plots and farmlands in Nigeria is a common occurrence and is mostly done by auto-mechanics and allied artisans with workshops on the roadside and open places, disposal of used oil indiscriminately to the soil which according to Atuanya (1987) affects its physical, biological and chemical properties, therefore making life uncomfortable for both plants and animals that live and feed in the soil including *Jatropha curcas*. Although, research work have been conducted on forest tree species using spent oil, but information on *Jatropha curcas* in scarce. Therefore, there is need to study the growth response or performance of *Jatropha curcas* seedlings grown on soil contaminated with spent engine oil, since *Jatropha curcas* is a very rich and economic plant.

There has been general awareness about the dangers of loosing economic tree species form our tropical high forest ecosystem including *Jatropha curcas*; this is due to low concerted efforts being made to cultivate the species (Omolaiyi *et al.*, 2005; Agbogidi, 2011). The indiscriminate disposal of spent engine oil has led to the disappearance of most economic tree species, the environmental impact of indiscriminate disposal of spent oil is one of the inevitable consequences of economic development. The effects of oil in the soil include depression and inhibition of plant growth by interfering with the soil water plant interrelationship (Agbogidi and Dolor, 2007). Oil in the soil has been reported to cause alteration in soil physico-chemical properties as well as the performance and yield of crop plants (Anoliefo and Vwioko, 1995; Anoliefo and Edegbai, 2000; Agbogidi and Nweke, 2005; Vwioko *et al.*, 2005; Agbogidi *et al.*, 2006a; Agbogidi *et al.*, 2006b) maintained that pollution of soil by spent lubricating oil has been shown to cause growth reduction in plants attributed mainly to the presence of heavy metals at toxic Concentration in soil. The terrestrial ecosystem and shore line in mechanic villages are important Agricultural land and any contact with spent oil may result in damage to soil or plant communities (Agbogidi *et al.*, 2005). Since some of the important tree species including *Jatropha curcas* exist in these areas (mechanic villages) there is need to study the growth response of *Jatropha curcas* in spent engine oil contaminated soil. This study has the objective of evaluating the growth performance of *Jatropha curcas* grown in spent engine oil contaminated soil.

Materials and Methods

Study area

The experiment was carried out at the research farm of the department of forestry and wildlife, Delta State University, Asaba Campus. Asaba is located within the tropical rain forest zone at latitude 6° 14'N and longitude 6° 49'E of the equator. The area is characterized with a total annual rainfall of 1,955mm, mean monthly rainfall of 1586 mm; mean monthly soil temperature at 100cm depth is 31.4°C and means monthly sunshine of 4.7 hours (Asaba meteorological station, 2010).

Source of soil sample: Soil sample was collected from the *Gmilina aborea* plantation behind the department of forestry and wildlife, Delta State University Asaba Campus.

Source of seeds: The seeds were obtained from the parent plant in Delta State University Asaba Campus

Source of spent engine oil: Spent engine oil was collected from one of the mechanic workshops in Asaba, Delta State.

Experimental design: Randomized Complete Block Design (RCBD) was used with three replicates for each treatment.

Procedure: The top soil used was thoroughly mixed with the appropriate spent oil level before the poly pot was filled up with 1.3kg weight of the contaminated soil. The levels of spent engine oil that was used are 0, 50,100, 150 and 200ml. thus by calculating the equivalent concentration of spent oil in the soil was 0.00, 3.45, 6.92, 10.39 and 13.86% of the oil per 1.3kg weight of the soil respectively. Seedlings of about two weeks old were transplanted into the contaminated soil in the perforated poly pot and were watered immediately and afterward every other day to field capacity. The experiment was replicated three times with five treatments. The set up was monitored for 12 weeks after transplanting, while parameters was measured fortnightly with effect from the second week after transplanting, the experiment was terminated 12 weeks after transplanting (WAT).

Data collected: The parameters considered were plant height (cm): This was measured using measuring tape from soil level to terminal bud at two weeks interval after transplanting, number of leaves: This was done by visual counting of the number of leaves for each seedlings per treatment, leaf area (cm²): This was done by tracing the leaves on a graph paper and the total area per plant was obtained by measuring the maximum leaf and the length and breadth of the leaf was multiplied by the correction factor 0.75 following the formula of (Agbogidi and Ofuoku., 2005), collar diameter: This was measured using veneer caliper every two weeks and Tolerance index:- This was measured using the formula below

$$T.I (\%) = \frac{NEO}{NEC} \times 100$$

Where

T.I = Tolerance index

NEO = number of emerged leaves/leaf of seedlings in oil contaminated soil

NEC = number of emerged leaves/leaf in control.

Data analysis: Data collected was subjected to analysis of variance (ANOVA) at 0.05 probability level while the significant means was separated using the Fisher's least significant difference (L.S.D) method.

Results and Discussion

The results of growth performance (plant height, number of leaves, leaf area and collar diameter of *Jatropha curcas* seedlings as influenced by various levels of spent engine oil in soil are presented in tables 1, 2, 3 and 4 respectively. The results showed that spent engine oil contaminated soil had a significant effects ($p \geq 0.05$) negatively on *Jatropha curcas* seedlings in terms of plant heights number of leaves, leaf area and collar diameter. The effect being spent engine oil concentration dependent. For example at 0.00 level of oil contamination 8 WAT, the plant height was 14.40cm, 13.03cm at 3.45 (%w/w) level of oil application to soil and 10.32cm at 13.86 (%w/w) level of oil in soil (Table 1). Significant reduction ($p \geq 0.05$) was observed in the parameters (plant height, number of leaves, leaf area and collar diameter) measured with increasing levels of spent engine oil (Tables 1-4) no death was recorded in all the seedlings, which indicates that *Jatropha curcas* seedlings tolerated all the oil levels used. Tolerance index of the seedlings exposed to oil contaminated soil decreased as oil levels increased (Table 5). It was observed that there was a complete leaf fall (defoliation) of *Jatropha curcas* seedlings both in control and contaminated soil one WAT, this is as a result of shock. However, the seedlings grown in the contaminated soils experienced leaf fall subsequently unlike those in control. This is responsible for the reduction in the number of leaves and leaf area (Table 2 and 3). For example the mean values of number of leaves at 12 WAT were 7.40 and 1.80 in 0.00 and 13.86 (%w/w) levels of oil respectively. While for leaf area the mean value was 102.65 and 9.10 in 0.00 and 13.86 (%w/w) levels of oil respectively at 12 WAT (Table 3). The reductions in the number of leaves and leaf area are spent engine oil concentrations dependent.

Spent engine oil influenced the growth and development of *Jatropha curcas* seedlings on plant height, number of leaves, leaf area, and collar diameter and tolerance index. The analyses of variance showed that there were significant differences in plant height and the highest mean value of 14.17cm was recorded for the control (0.00%) level of oil concentration. This result is in agreement with the findings of Oyin and Kassim (2006) who reported that the heights of *Celosia agentea* decreased as the concentration spent engine oil increased.

For number of leaves, leaf area and collar diameter, similar results were obtained with the control having the highest mean value of 5.59, 82.99 and 3.11 respectively which also confirm the report of Oyin and Kassim (2006) who reported that number of leaves, leaf area and collar diameter of the plant decreased as spent engine oil concentration in the soil increased. The analyses of variance also showed that there were significant differences ($p \geq 0.05$) in the tolerance index. The highest mean value 71.92 was recorded for 3.45% level of oil concentration which is the lowest level of contamination. This indicates that tolerance index decreased as concentration of spent engine oil increased. This result is in agreement with the work of Anoliefo and Vwioko, (2001) who reported that *Chromolaena odorata* grown in control 0.00% and 3.45% levels oil contaminated soil showed high level of tolerance than the others.

The result from this investigation showed that the highest level of oil (13.86%) in the soil has the greatest effect on the seedling of *Jatropha curcas*. It was also observed that the plant grow on the contaminated soil experienced chlorosis of leaf unlike those grown in control. Thirdly it was observed that 6 WAT, 3.45% 10.39 and 13.86 levels of oil concentration has the greatest effects on the plant height while 6.92% level of oil concentration had its greatest effect on plant height at 8 WAT. For number leaves, 6.92%, 10.39% and 13.86% levels of oil concentration had the greatest effect on the plant at 10 WAT while 3.45% level of oil present in the soil had its greatest effect on tolerance index at 12 WAT. Spent engine oil influenced the growth and development of *Jatropha curcas* seedlings on plant height, number of leaves, leaf area, and collar diameter and tolerance index. The analyses of variance showed that there were significant differences in plant height and the highest mean value of 14.17cm was recorded for the control (0.00%) level of oil concentration. This result is in agreement with the findings of Oyin and Kassim (2006) who reported that the heights of *Celosia agentea* decreased as the concentration spent engine oil increased. For number of leaves, leaf area and collar diameter, similar results were obtained with the control having the highest mean value of 5.59, 82.99 and 3.11 respectively which also confirm the report of Oyin and Kassim (2006) who reported that number of leaves, leaf area and collar diameter of the plant decreased as spent engine oil concentration in the soil increased. The analyses of variance also showed that there were significant differences ($p \geq 0.05$) in the tolerance index. The highest mean value 71.92 was recorded for 3.45% level of oil concentration which is the lowest level of contamination. This indicates that tolerance index decreased as concentration of spent engine oil increased. This result is in agreement with the work of Anoliefo and Vwioko, (2001) who reported that *Chromolaena odorata* grown in control 0.00% and 3.45% levels oil contaminated soil showed high level of tolerance than the others.

Conclusion

The result from this investigation showed that the highest level of oil (13.86%) in the soil has the greatest effect on the seedling of *Jatropha curcas*. It was also observed that the plant grow on the contaminated soil experienced chlorosis of leaf unlike those grown in control. Thirdly, it was observed that 6 WAT, 3.45% 10.39 and 13.86 levels of oil concentration has the greatest effects on the plant height while 6.92% level of oil concentration had its greatest effect on plant height at 8 WAT. For number leaves, 6.92%, 10.39% and 13.86% levels of oil concentration had the greatest effect on the plant at 10 WAT while 3.45% level of oil present in the soil had its greatest effect on tolerance index at 12 WAT.

Table 1. Plant height (cm) of *Jatropha curcas* as influenced by different spent engine oil levels in soil.

Oil in soil (%w/w)	WAT/plant height						Mean
	0	2	4	6	8	10	
0.00	12.77	13.27	14.20	14.40	14.80	15.60	14.17a
0.45	13.05	13.01	12.93	13.03	13.10	13.87	13.17b
6.92	11.45	11.43	11.17	11.21	11.75	11.84	11.48c
10.39	10.60	10.50	10.51	10.54	11.12	11.15	10.74d
13.86	10.37	10.27	10.04	10.32	10.30	10.87	10.36e
Means	11.65	11.70	11.77	11.90	12.21	12.67	

Means with different letters are significantly different at ($p \leq 0.05$) level of significance using Fisher's least significant difference (LSD).

Table 2. Effect of spent engine oil on number of leaves of *Jatropha curcas* seedling

Oil in soil (%w/w)	WAT/number of leaves						Mean
	0	2	4	6	8	10	
0.00	4.20	4.67	5.27	5.60	6.40	7.40	5.599a
3.45	3.73	3.20	3.20	2.87	3.13	3.40	3.28b
6.92	2.93	3.13	3.13	2.67	2.40	5.53	2.80c
10.39	2.80	2.67	3.00	2.53	1.93	2.20	2.52d
13.86	1.93	2.33	2.07	1.93	1.27	1.80	1.89e

Means with different letters are significantly at ($p \leq 0.05$) level of significance using Fishers least significant (LSD).

Table 3. Leaf area (cm^2) of *Jatropha curcas* as affected various levels of spent engine oil contamination in soil.

Oil in soil (%w/w)	WAT/leaf area						Mean
	0	2	4	6	8	10	
0.00	59.09	67.72	79.39	89.88	99.22	102.65	82.99a
3.45	48.48	57.12	46.88	46.11	42.68	44.45	47.62b
6.92	34.77	43.24	36.68	36.04	30.83	31.84	35.58c
10.39	21.57	28.12	21.47	20.82	17.25	17.98	21.20d
13.86	9.00	12.56	9.80	9.59	6.88	9.10	9.49e

Means with different letters are significantly different at ($p \leq 0.05$) level of significance using Fisher's least significant difference (LSD).

Table 4. Collar diameter (cm) of *Jatropha curcas* as influenced by different spent engine oil level in soil.

Oil in soil (% w/w)	WAT/collar diameter						Mean
	0	2	4	6	8	10	
0.00	2.21	2.43	2.99	3.47	3.66	3.87	3.11a
3.45	2.25	2.43	2.73	2.97	3.08	3.22	2.78b
6.92	2.11	2.33	2.65	2.71	2.75	2.91	2.58c
10.39	2.11	2.22	2.29	2.43	2.45	2.50	2.33d
13.86	1.94	1.99	2.08	2.04	2.05	2.11	2.04e
Means	2.12	2.28	2.55	2.72	2.80	2.92	

Means with different letters are significantly different at ($p \leq 0.05$) level of significance using Fisher's least significant difference (LSD)

Table 5. Effects of spent engine oil on tolerance index (%) of *Jatropha curcas* seedlings

Oil in soil (% w/w)	WAT/Tolerance index						Mean
	0	2	4	6	8	10	
0.00	4.20	4.67	5.33	5.67	5.47	7.40	5.46a
3.45	111	79.67	71.89	57.54	63.20	48.22	71.92b
6.92	81.22	72.89	65.77	54.76	49.28	34.49	59.24c
10.39	67.39	59.56	63.66	50.46	39.90	31.90	52.15d
13.86	57.78	54.11	43.11	38.12	31.79	26.12	41.89e
Means	64.32	54.1	50.01	40.71	37.93	29.63	

Means with different letters are significantly different at ($p \leq 0.05$) level of significance using Fisher's least significant difference (LSD)

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