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Research Article

EFFECTS OF CRUDE OIL AS A SOIL CONTAMINANT ON SEEDLING GROWTH OF *Jatropha curcas* .L

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ABSTRACT

A study was conducted in 2010 to evaluate the effects of crude oil as a soil contaminant on the performance of *Jatropha curcas* seedlings in Asaba, Delta State, Nigeria. Oil concentrations used were 0.0, 2.0, 4.0, 6.0, 8.0 and 10.0% w/w. The experiment was arranged in a randomized complete block design with four replicates and monitored for 10 weeks after transplanting. The results showed that contamination of soil with crude oil significantly reduced ($P \geq 0.05$) the performance of *Jatropha curcas* seedlings as regards plant height, number of leaves, leaf area and collar diameter when compared with seedlings grown in the uncontaminated soils. The performance of the seedlings was oil concentration dependent. Other symptoms observed at the higher levels of oil treatments were yellowness of leaves, leaf fall/drop, chlorosis, growth retardation and stagnation as well as wilting. This study has shown that crude oil in soil has a highly significant effect of reducing the performance of *J. curcas* seedlings. The oil level most tolerated by the plant is 2.0% w/w and above this level, significant reductions were recorded. This study has great implications on the sustainability of this multipurpose species, which has been identified as a potential biofuel species.

Key Words: performance, *Jatropha curcas* seedlings, crude oil, soil

INTRODUCTION

Jatropha curcas is a perennial shrub that is native to Central America. It is now widely cultivated in tropical and subtropical regions of the world becoming even naturalized in other areas (Achtein, 2008). Commonly called Barbados nut, purging nut or physic nut, the plant produces flowers and fruits throughout the year. It is resistant to a high degree of acidity (Henry, 2009). The fruit contains 37.5% shell and 62.5% seeds (Jepsen *et al*., 2006). Seeds resemble castor in shape, black in colour and are 42% husk and 58% kernel. The seeds contain 27-40% oil that can be processed to produce a high quality biodiesel fuel useable in a standard diesel engine (Biswas *et al*., 2006; Kureel, 2006; Wini *et al*., 2006). Achten *et al*. (2008) noted that *J. curcas* is mainly cultivated for extraction of biodiesel and is one of the best sources of biodiesel. Achten *et al.* (2008) further maintained that one-hectare of *J. curcas* yields 6-7MT of seeds while one tonne of *J. curcas* seeds yields 30kg oil product and 700kg oil cake. The rapid growth and development of *J. curcas* will represent the most immediate and available response of coping with depleting oil reserves, meeting growing energy depend in developing countries like Nigeria i.e. to support development in rural areas. The renewed interest in Jatropha cultivation could also reduce dependence on a limited number of exporting nations by diverting their energy sources and supplies as well as to challenge emerging economies in tropical regions to supply the global energy market with competitive price liquid biofuel besides stimulating economic growth, improving the environment and reducing dependency on imported oil (Kureel, 2006; Tigere *et al*., 2006). Economically, *J. curcas* is a medicinal plant: the seeds prevent constipation, the sap for wound healing and bleeding, the leaves as tea against malaria, and a potential source of herbal drugs in dental complaints. The plant also has the possibility of reclaiming marginal soils by reanchoring the soil with its substantial root and reduces possibility of erosion (Jepsen *et al*., 2006; Openshaw, 2000). Openshaw (2000) also reported that *J. curcas* is planted in form of hedges around gardens or fields to protect the crops against roaming planted to demarcate boundaries of fields and homesteads and as a source of shade for coffee plants in India and Cuba (Kumar *et al*., 2008a). Although *J. curcas* grows best in sandy well – drained soils, it also does well in warmer areas, as it can withstand severe heat, light frost for not too long, very poor soils and grows in saline conditions (Kumar *et al*., 2008b). Food production and transport are particularly dependent on diesel engines and biodiesel is a crucial part of bringing energy security benefits to the global food supply. In times of international terrorism there are heightened concerns about nuclear proliferation and energy security argues that the future must belong to bioenergy. If we can achieve energy security, we can not only free ourselves from dependence on fossil fuels, we can also realize environmental security and a whole host of other central developmental and poverty alleviation goals. This is because decreasing oil production from almost all the oil reserves is attracting the world's eyes towards renewable energy sources.

By promoting a shift towards low carbon economic activities, governments can not only help avoid dangerous climate change impacts but can also make the region more

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competitive, contributing to a faster recovery from the current economic slow down. The oil industry needs to be prepared for tomorrow, even in these uncertain times *Jatropha* and other non-feed crops produce biofuels and hold particular promise for sustainable development and a sustainable environment (Forson *et al.*, 2004). Its use is considerably less expensive feedstock, gives the producer a significant cost advantage over oil petroleum products. *Jatropha* and other non-food oil-bearing crops are the cheapest and the most viable business propositions. *Jatropha* can bring significant environmental benefits. It can replace jet fuel and diesel from petroleum without interfering with food crops or leading to the clearing of forests (Sukarin *et al.*, 1987). The good thing about the plant is that a tree shrub that lives for a longtime, doing its job, producing oil and sequestering lots of CO_2 from the atmosphere is produced. It can as well help to increase income from plantations and agro-industries besides helping to increase rural incomes, self-sustainability and alleviation of poverty. Biodiesel produced from *Jatropha* is one of the most promising solutions for tackling the growing carbon emissions from transport. *Jatropha* cultivation has a huge potential for replication worldwide improving the livelihood of many more (Biswas *et al*, 2006).

Presently, *J. curcas* found in Nigeria are those traditionally used as hedging plants and grave markers. Most recently, research institutes and investors have started establishing plantation of the plant because of its potential biodiesel production (Onyeme *et al.*, 2008; Ige *et al.*, 2010). The ability of *J. curcas* to grow in gravelly, sandy, degraded, acidic, poor/marginal soil according to Openshaw (2000) and Jepsen *et al*. (2006) has provided a basis for this investigation. Crude oil pollution is an inevitable phenomenon in oil producing and consuming areas worldwide (Agbogidi and Eshegbeyi, 2006). It stems from human error, accidental discharge and other sources (Agbogidi and Ayelo, 2010). The severity of oil pollution effects varies with the quantity, plant species, age of the plant, adequacy of the responses as well as other factors (Vwioko *et al.*, 2006; Agbogidi, 2009a). Oil pollution has deleterious effects on soil hence significant effects on plant growth. Although literatures abound on the susceptibility of plant species to crude oil and its products (Anoliefo and Edegbai, 2000; Agbogidi *et al*., 2006; Anoliefo *et al*., 2006; Bamidele *et al*., 2007; Agbogidi, 2009b), there is scarcity of documented information on the influence of crude oil on *J. curcas.* It is against this background that a study as this has been embanked upon to provide information on the performance of *J. curcas* seedlings as affected by crude oil in soil with a view to establishing the critical level this valuable multipurpose species can be significantly affected.

MATERIALS AND METHODS

The study was conducted in 2010 at latitude $6^0$14'N and longitude $6^0$49'E (Asaba Meteorological Office, 2010) at the nursery site of the Department of Forestry and Wildlife, Delta State University, Asaba Campus, Nigeria. Matured fruits were harvested from the parent plants in Asaba, Delta State. The fruits were depulped mechanically to extract the seeds. Healthy seeds were selected and sorted out. Viability tests were carried out on the seeds using floatation technique. The depulped seeds (600) in number were sown in the Departmental nursery and the basic nursery techniques were observed. The soil treatment was thoroughly mixed with appropriate crude oil levels before the polypots (10/15cm in dimension) were each filled up with the oil-soil mixture. Oil concentrations used were 0.0, 2.0, 4.0, 6.0,8.0 and 10.0% w/w . The soil sample was obtained as a pooled sample from the Gmelina plantation behind the Departmental office. The soil was air-dried and passed through a 2mm sieve. The crude oil was obtained from the Nigeria National Petroleum Corporation (NNPC), Warri., Delta State.

The seedlings (6 weeks of age) were transplanted into the oil–contaminated soil and the uncontaminated soil (control) in the polypots and watered immediately to field capacity and after wards, every other day till the end of the experiment. There were therefore six treatments, replicated four times and arranged in randomized complete block design. One seedling was transplanted into each polypot and each treatment comprised 10 polypots indicating a total of 180 seedlings of relatively the same height were transplanted. The set-up was monitored for 10 weeks after transplanting (WAT) while growth parameters were measured fortnightly with effect from the second week after transplanting. Plant height was determined with a meter rule at the distance from soil level to the terminal bud; number of leaves was by visual counting of the leaves, leaf area was measured by tracing the margins of the leaf on a graph paper and the total leaf area/plant was obtained by counting the leaf number of 1-cm squares following the procedure of Agbogidi and Eshegbeyi (2006). The collar diameter was determined by measuring at two centimeter above soil level with vennire calipers. Data obtained were exposed to one-way analysis of variance (ANOVA) and the significant means were separated with the Duncan's Multiple Range Tests (DMRT) using SAS (2005).

RESULTS AND DISCUSSION

As shown in Tables 1, 2, 3 and 4, contamination of soil with crude oil significantly (P≥0.05) reduced all the growth indices assessed. Plant height, number of leaves, leaf area and collar diameter were significantly affected by oil treatment at (P≥0.05) when compared with seedlings grown in the uncontaminated soils. The growth of seedlings was progressively poorer as the level of oil increased indicating that the performance of the seedlings was oil concentration-dependent. For example, while 25.8cm and 22.9cm height values were recorded for seedlings grown in 0.0 and 2.0% w/w of oil at 6 WAT, 16.9cm and 16.6cm were obtained for seedlings exposed to 8.0 and 10.0% w/w of the oil concentration respectively. The same trend was also observed in number of leaves, leaf area and collar diameter (Tables 2, 3 and 4) respectively.

Table 1. Plant height (cm) of *Jatrapha curcas* seedlings grown in soil contaminated with crude oil

Oil in soil	Plant height/WAT					
(% w/w)	2	4	6	8	10	Means
0.0	18.9	20.4	23.6	25.8	26.7	23.1a
2.0	18.6	20.2	22.9	25.3	25.8	22.6b
4.0	18.0	18.3	18.4	18.6	18.8	18.4c
6.0	17.4	17.5	17.6	17.7	17.8	17.6d
8.0	17.1	17.2	17.3	16.9	16.8	17.6d
10.0	16.9	17.0	16.8	16.6	16.5	16.8e
Means	17.8	18.4	19.4	20.2	20.0	

Means with different letters are significantly different at P≤0.05) level by Duncan's Multiple Range Tests.

Table 2. Number of leaves of *Jatrapha curcas* seedlings as affected by crude oil contaminated of soil

Oil in soil	Number of leaves/WAT					
(% w/w)	2	4	6	8	10	Means
0.0	5.1	6.3	7.8	8.5	9.7	7.3a
2.0	5.0	6.2	7.6	8.4	9.6	7.4a
4.0	4.8	5.2	5.4	5.6	5.7	5.3b
6.0	4.7	5.0	5.1	5.1	5.1	5.0c
8.0	4.6	4.3	4.2	4.1	4.0	4.2d
10.0	4.3	4.2	4.1	4.0	3.8	4.1e
Means	4.75	5.20	5.70	5.95	6.32	

Means with different letters are significantly different at P≤0.05) level by Duncan's Multiple Range Tests.

Table 3. Lead area (cm^2) of *Jatrapha curcas* seedlings as influence by crude oil in soil

Oil in soil	Leaf area/WAT					
(% w/w)	2	4	6	8	10	Means
0.0	126.4	267.2	324.4	386.6	524.3	325.8a
2.0	120.2	254.1	320.2	382.2	519.1	319.2b
4.0	118.2	225.6	260.2	286.3	271.4	232.3c
6.0	115.1	201.7	214.6	216.7	219.2	193.5c
8.0	110.0	126.9	114.7	112.6	100.2	112.9e
10.0	101.0	118.1	100.1	95.5	90.3	101.0f
Means	115.2	198.9	222.4	214.5	287.4	

Means with different letters are significantly different at P≤0.05) level by Duncan's Multiple Range Tests.

Table 4. Collar diameter (cm) of *Jatrapha curcas* as affected by crude oil contamination of soil

Oil in soil	Collar diameter /WAT					
(% w/w)	2	4	6	8	10	Means
0.0	0.73	0.90	1.10	1.31	1.49	1.11a
2.0	0.73	0.86	1.09	1.20	1.38	1.05a
4.0	0.71	0.74	0.82	0.89	1.04	0.84b
6.0	0.70	0.73	0.80	.8	1.00	0.81c
8.0	0.70	0.66	0.64	0.60	0.58	0.63d
10.0	0.69	0.64	0.62	0.54	0.52	0.60e
Means	0.71	0.76	0.85	0.90	1.00	

Means with different letters are significantly different at P≤0.05) level by Duncan's Multiple Range Tests.

Other visible symptoms were yellowness of leaves, leaf drop chlorosis necrosis growths retardation and stagnation as well as wilting at the highest level (10.0% w/w) of crude oil treatment of soil. These observations are similar to the reports of Achuba (2006), Anoliefo *et al*. (2006), Agbogidi and Dolor (2007), Agbogidi *et al.* (2007), Agbogidi (2009b), Agbogidi 2010 on groundnut, cowpea, common beans, dikanut, maize, Gmelina and soyabeans respectively. Yellowness of leaves could be due to nutrient immobilization as oil pollution has been reported to cause unavailability of some essential nutrients while some toxic ones may be more readily available (De Jong, 1980; Benka–Coker and Ekundayo, 1995; Benka–Coker and Ekundayo, 1997). The observed leaf drop/fall and wilting could be linked to the inability of the seedlings to absorb water because they were watered like their counterparts in the uncontaminated subplots. This could have stemmed from the alteration caused by the presence of the oil in soil and this observation is in agreement with the findings of Atuanya (1987) and Ekundayo and Obuekwe (1997) that oil in soil affects the physical, chemical and biological properties of the soil.

Growth retardation and stunting could have been attributed to both soil-plant-water interrelations as well as a disruption in the xylem and phloem vessels due to the adulterated soil structure and this could have culminated in the over growth stagnation in seedlings grown in the highest level of oil contamination in the highest level of oil contamination. This observation lays credence to the reports of Agbogidi and Ofuoku (2005) and Agbogidi and Eshegbeyi (2006) that oil level seemed to exert the greatest influence on plant growth and yields. The presence of other toxic components of the crude oil as well as heavy metals could have also accounted for the observed growth reduction, stunting and stagnation in the highest levels of oil application to soil as observed in the present study. This study has shown that crude oil in soil has a highly significant effect of reducing the performance of *J. curcas* seedling in terms of plant height, number of leaves, leaf area and collar diameter. The oil level most tolerated (critical) by the plant is 2.0% w/w above this level, significant reductions were recorded.

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