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An Assessment of the Growth of *Irvingia gabonensis* (Aubry-Lecomte Ex O'Rorte) Bail Seedlings as Influenced by Crude Oil Contamination of Soil

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Abstract: An assessment of the growth responses of *Irvingia gabonensis* seedlings as influenced by various level of crude oil contamination of soil was carried out in Asaba, Delta State, Nigeria. The crude oil levels used were 0.00 (control), 2.19, 4.38, 6.58 and 8.77% by weight of the soil samples. Growth responses of the test plant were measured in terms of plant height, number of leaves, leaf area, collar girth and dry weight yield. A negative interaction was observed between the soil crude oil content and the seedling performance of this multipurpose forest fruit tree species. For example, the leaf area of seedlings grown in the uncontaminated soil was 66.16 while 46.00 cm^2 was recorded for seedlings subjected to 8.77% of oil. The present study has shown that crude oil contamination of soil has a highly significant effect ($p \leq 0.05$) of reducing the growth of *Irvingia gabonensis* seedlings. *Irvingia gabonensis* can therefore be recommended for reforestation and bioremediation of low concentration crude oil impacted soils.

Key words: Crude oil, soil contamination, *Irvingia gabonensis*, growth responses

INTRODUCTION

Irvinia gabonensis (Aubry-Lecomte ex O' Rorke) Bail also known as the wild mango or Dikanut has a mango-like edible fruits. This forest tree may be readily recognised by its dense dark evergreen foliage and characteristic stipules (Keay *et al*., 1964; Etukudo, 2000). Keay *et al*. (1964) maintained that *I. gabonensis* attains a height of about 80 ft high and 6 ft in girth. The tree is usually fluted and slightly buttressed. The bark is grayish, smooth or very slightly scaly. The leaves are 2-6 inches long by 1-2.5 inches, broad elliptic and slightly rounded at the base, leathery, dark green and glossy above with a distinct stalk of above 0.2 inches (Keay *et al*., 1964).

I. gabonenesis flowers between November and March: and fruits in the rainy season, between April and September. The flowers are yellowish to greenish white borne in slender clustered racemes or small panicles among the leaves. The fruits are yellowish, 2-3 inches long with a yellowish fibrous pulp surrounding a large stone (Bada and Adewusi, 1994). The wood according to Thikakul (1985) is pale brown, hard, very heavy and fine -grained. It is used as a general- purpose timber (Leakey, 1999). The fruits of *I. gabonenesis* resemble the cultivated mango (Koyejo and Omokhua, 2001). The fruit pulp is juicy and widely eaten although its taste varies between sweet and bitter (Etukudo, 2000). The pulp can be used for the preparation of juices, jellies and jams (Okafor, 1985). The juice has a great wine making potential (Bassey, 1982; Leakey *et al*., 2003). Etukudo (2000) noted that in the rural areas of the tropics, *I. gabonensis* fulfils a very useful role in improving food quality by providing proteins, vitamins, minerals and fats and as a non-timber forest product, it plays an important role in alleviation poverty (Ndoye *et al*., 1998; Agbogidi and Okonta, 2003). The kernels of *I. gabonensis* are used as a source of oil for making soap and as a thickening agent in traditional soups (Okafor, 1980; Abbiw, 1990; Shiembo *et al*., 1996).

Irvingia gabonensis comes first in the priority-setting exercise in humid lowland of West Africa for domestication (Daliziel, 1987; Ayuk *et al*., 1999; Leakey, 1999; Leakey *et al*., 2003). It also has a high potential for agro forestry practices (Okafor, 1985; Okafor, 1991; Okafor and Lamb, 1994; Okafor and Okolo, 1996; Okafor *et al*., 1996; Leakey, 1999; Koyejo and Omokhua, 2001).

The kernel of *I. gabonensis* features prominently in local and international trade in West Africa (Ejiofor and Okafor, 1997; Elias *et al*., 1999). The kernels are highly traded (Okafor, 1980; Ndoye *et al*., 1998) and it is transformed into a paste used in the preparation of sauces (Elias *et al*., 1999). Different components of the plants including the bark, kernel and pulp are used as medicine (Duguma *et al*., 1990). The tree is usually preserved on farms to provide shade for some crops (Leakey, 1999) and it has been reported to restore soil fertility (Shiembo *et al*., 1996).

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Due to the high rates of deforestation, low density of the species in the remaining forests as well as its value in existing and future international markets as a potential source of income in the region, there is a threat to the survival and sustainability of *I. gabonensis* (Okafor, 1980; Leakey, 1999). The increased prospection of oil in the rainforest zone especially in the Niger Delta area of Nigeria where this multipurpose forest fruit tree species are found in its natural habitat has further contributed to the diminishing population of *I. gabonensis*.

Crude oil is a vital source of petroleum, which sustains and promotes growth of many nations including Nigeria. In Nigeria, crude oil activities are predominant in the southern states, which are located in the humid tropical forest zone where most of the forest trees abound. Oil spillage usually occurs during the processes of oil exploration and exploitation through leakages of oil pipelines and flow lines, accidents and sabotage to well heads leading to the contamination or pollution of soils, arable and other components of the environment impacting negatively on crop plants, the forests and their rich biodiversities (Baker, 1970; Nicolotti and Eglis, 1998; Nwilo, 1998; Agbogidi *et al*., 2002; Siddiqui and Adams, 2002).

Although research by Terge (1984), Malallah *et al*. (1995) and Egharevba and Osunde (2001) showed that crude oil pollution of soil has a significant effect on forest tree species, a systematic study on the assessment of crude oil contamination of soil on the growth of *I. gabonenesis* is scarce. The present study has been undertaken to assess the growth responses of *Irvingia gabonensis* as influenced by crude oil contamination of soil.

MATERIALS AND METHODS

The study was conducted in the teaching and research farm of the Delta State University, Asaba Campus, Delta State, Nigeria. Asaba (latitude 6°14′ N, longitude 6°49′ E, temperature 28±6°C, rainfall 1505-1849 mm, relative humidity 69-80% and monthly sunshine 4.8 h) is located in the rainforest agro-ecological zone (Asaba Meteorological Bulletin, 2003).

The mature fruits of *Irvingia gabonensis* were harvested from selected tree in Delta State University, Asaba Campus. The seeds were mechanically depulped and sun dried for two days. The seeds were later presoaked in water for four hours following the method of Elias *et al*. (1999). The viable seeds, determined by simple flotation technique were then sown in the nursery.

The crude oil used (with specific gravity of 0.8768 g cm^{-1}) was obtained from the Nigerian National Petroleum Corporation (NNPC), Warri, Delta State.

The soil mixture used was a 2.1 ratio of the topsoil to well decomposed organic manure. The mixture was air-dried and passed through 2 mm sieve. The soil mixture 1.00 kg (1,000 g) set aside for each treatment was thoroughly mixed with the appropriate volume of crude oil before the poly-pots were each filled with 1.00 kg weight of the oil contaminated soil. The crude oil pollution contamination levels used were 0.00% (control), 2.19, 4.38, 6.58 and 8.77% of the oil per wet weight (% w/w) of soil respectively.

The experimental set-up comprised five treatments; each consisted of 14 poly-pots with three replications. The experimental design adopted was a randomized complete block design. A seedling of *Irvingia gabonensis* in the nursery was transplanted into the poly-pots at 11 weeks old and watered to field capacity immediately and afterwards, every other day until the end of the trial following the procedure of Agbogidi and Ejemete (2005) and Agbogidi and Eshegbeyi (2006). The set-up was monitored for 10 Weeks After Transplanting (WAP) while growth characters were measured fortnightly with effect from the second week after transplanting. Plant height was measured with a meter rule at the distance from the soil level to terminal bud. The number of leaves was determined by counting while the leaf area was determined by tracing the leaves on a graph paper and the total leaf area per plant was obtained by counting the number of 1cm squares. Collar girth was measured with veneer calipers. At the end of the experiment (10 WAT), the seedlings were harvested and separated into leaves, stems and roots. They were oven-dried at 85°C for 22 h following the method of Anonymous (1966) after which, the dry weights were taken. Plant variables were analysed with analysis of variance while the Duncan's multiple range test was used to evaluate statistical differences among the significant means.

RESULTS

The height measurements of *Irvingia gabonensis* seedlings are indicated in Table 1. Significant reductions ($p = 0.05$) in height were observed for all treatments relative to the control at each time interval. At the 2.19% oil treatment, a height of 36.68 cm was recorded compared to the control of 38.44 cm. This result showed that the height of the control plants was significantly greater than those sown in soil treated with crude oil ($p = 0.05$). The rate of increase in the height of plants was also less in the soil treated with 4.38, 6.58 and 8.77 % oil compared to that of the control. Growth stunting was observed for seedlings subjected to 6.58 and 8.77% treatments as from the 8th weeks after transplanting.

The effects of crude oil contamination level on the number of leaves of *I. gabonensis* seedlings are presented in Table 2. Crude oil application to soil at all intensities resulted in a significant reduction (p = 0.05) in the number of leaves when compared with the seedlings grown in the control soils. Defoliation or leaf drop, leaf burnt, leaf withering and suppression of leaf initiation were evident in *Irvingia gabonensis* seedlings grown in soils amended with higher oil levels.

Crude oil contamination of soil significantly reduced (p = 0.05) total leaf area in the seedlings exposed to crude oil amendment compared to their counterparts in the control. The leaf area of the control plants was significantly greater (p = 0.05) than that of plants grown in soils amended with 2.19% crude oil (59.81 cm^2) and 4.38 and 6.58% oil treated soil (54.10 cm^2) and (48.81 cm^2) respectively at p = 0.05 (Table 3). No significant differences existed in the leaf area of *I. gabonensis* seedlings grown in 6.58 and 8.77% oil at the 5% probability level.

There was a progressive increase in the collar girth of *I. gabonensis* seedlings grown in the uncontaminated soil (0.00%) and soils treated with 2.19% crude oil (Table 4). No significant differences were observed in seedlings grown in the control and those subjected to 2.19% oil at p = 0.05. A negative relationship was however observed in the collar girth of the seedlings with increasing level of oil in the soil.

There was a significant decrease (p = 0.05) in the dry weight accumulation of the seedlings with an increase in oil levels (Table 5). This result showed that a negative relationship has been observed between the dry matter yield of *I. gabonensis* seedlings and the concentration of the oil applied to the soil.

Table 1: Height (cm) values of *Irvingia gabonensis* seedlings as influenced by various levels of crude oil contamination of soil

	Plant height/weeks after transplanting (WAT)					
Oil level in soil % (w/w)	2	4	6	8	10	Means
0.00% (control)	35.24	36.41	39.05	40.10	41.41	38.44a
2.19	35.02	35.84	36.68	37.04	38.85	36.68b
4.38	34.66	34.81	34.86	35.41	35.49	35.04c
6.58	34.05	34.46	34.49	34.49	34.49	34.37d
8.77	32.40	33.45	33.48	34.48	34.48	33.65d

Means with different superscripts are significantly different at p = 0.05 using Duncan's Multiple Range Test (DMRT)

Table 2: Number of leaves of *Irvingia gabonensis* seedlings as influenced by various levels of crude oil contamination of soil

	No. of leaves/weeks after transplanting (WAT)					
Oil level in soil % (w/w)	2	4	6	8	10	Means
0.00% (control)	11.00	12.68	13.84	14.94	15.54	13.40a
2.19	10.45	10.86	11.18	11.74	12.01	11.24b
4.38	10.20	10.42	10.48	10.73	10.91	10.58b
6.58	10.14	10.32	10.02	9.04	9.00	9.70c
8.77	10.10	10.10	9.14	9.00	7.64	9.25d

Means with different superscripts are significantly different at p = 0.05 using Duncan's Multiple Range Test (DMRT)

Table 3: Leaf area (cm^2) of *Irvingia gabonensis* seedlings as influenced by various levels of crude oil contamination of soil

	Leaf area/weeks after transplanting (WAT)					
Oil level in soil % (w/w)	2	4	6	8	10	Means
0.00% (control)	53.70	64.56	70.81	73.04	78.63	66.16a
2.19	52.46	58.13	60.02	62.63	65.83	59.81b
4.38	50.13	52.16	54.96	56.18	57.10	54.10c
6.58	48.07	48.78	46.16	46.00	45.04	48.81d
8.77	47.04	47.46	46.02	45.28	44.21	46.00d

Means with different superscripts are significantly different at p = 0.05 using Duncan's Multiple Range Test (DMRT)

Table 4: Mean collar girth (cm) values of *Irvingia gabonensis* seedlings as influenced by various levels of crude oil contamination of soil

	Collar girth/weeks after transplanting (WAT)					
Oil level in soil % (w/w)	2	4	6	8	10	Means
0.00% (control)	2.50	2.64	2.72	2.84	2.94	2.72a
2.19	2.40	2.51	2.60	2.72	2.80	2.60a
4.38	2.24	2.26	2.25	2.25	2.26	2.25b
6.58	2.20	2.18	2.16	2.15	2.13	2.16c
8.77	2.15	2.13	2.10	2.08	2.05	2.10c

Means with different superscripts are significantly different at p = 0.05 using Duncan's Multiple Range Test (DMRT)

Table 5: Mean dry weight (g) values of *Irvingia gabonensis* seedlings as influenced by various levels of crude oil contamination of soil

Oil level in soil % (w/w)	Plant parts			
	Leaf	Stem	Root	Means
0.00% (control)	8.94	9.46	6.04	8.15a
2.19	6.62	7.67	4.59	6.29b
4.38	3.30	5.26	2.48	3.68c
6.58	3.00	3.76	1.98	2.91d
8.77	2.26	3.41	1.80	2.49d

Means with different superscripts are significantly different at p = 0.05 using Duncan's multiple range test (DMRT)

DISCUSSION

Results obtained from this study indicated that crude oil of different concentrations adversely affected the performance of the test plant. Mallallah *et al.* (1995) observed a 64.8% decrease in the growth of *Vicia faba* in the presence of crude oil while Anoliefo (1991) reported that the seeds of *Citrullus vulgaris* exposed to crude oil for five minutes and above did not develop beyond radicle and plumule emergence. Nasamu (1996) reported a general depression in the root growth of *Colocasia esculenta* and *Xanthosoma sagittifolium.* Gill *et al.* (1992) and Bamidele and Agbogidi (2000) reported that a reduction in shoot growth following oil pollution is a direct result of a reduction in root growth probably because roots are important organs for the absorption and translocation of water and mineral nutrients (Gill *et al.*, 1992). Asuquo *et al.* (2002) maintained that the growth of okra and fluted pumpkin decreased significantly with an increase in crude oil concentrations. The observed leaf drop and leaf withering followed by a reduction in all the assessed growth variables including dry matter yield could be attributed to heavy metal toxicity. This finding agrees with the report of Khan and Frankland (1983). Ochiai (1995) maintained that heavy metal toxicity as well as the difficulty of plants to obtain sufficient water and mineral nutrients from oil polluted soils normally account for their reduced growth characters and poor performance. Absorption of toxic oil fractions through the roots could cause poisoning of plant by disruption cell membranes and cellular organelles (Getter *et al.*, 1984) required for vital metabolic processes. Reduced oxygen exchange between the soil and the atmosphere could have affected root function thereby leading to reductions in the growth responses assessed.

Reduction in the dry matter yield of *I. gabonensis* seedlings subjected to higher pollution levels was expected as the plants had stopped growing normally. The observed reduced biomass production with increasing oil intensity confirms the findings of Baker (1968, 1970) who showed that as hydrocarbons from oil polluted soil accumulate in the chloroplast of leaves, photosynthetic ability of the leaves becomes reduced, affecting translocation in affected plants probably due to obstruction of the xylem and phloem vessels hence reduction in photosynthate and dry matter content. Reduced dry weight of plants including forest species following crude oil pollution of soil has earlier been reported by Culter *et al.* (1991), Agbogidi (2003) and Agbogidi and Ofuoku (2005).

The present study has demonstrated that crude oil contamination of soil has a highly significant effect of reducing the growth responses of *Irvingia gabonensis* seedlings. It also indicated that *I. gabonensis* has some bioremediation potentials especially at low concentrations in crude oil impacted areas.

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