

Effects of Crude Oil Contaminated Soil on Biomass Accumulation in *Jatropha curcas* L. Seedlings

Agbogidi, O.M.

Department of Forest and Wildlife,
Faculty of Agriculture, Delta State University,
Asaba Campus, Delta State, Nigeria.

omagbogidi@yahoo.com

07038679939 and 08056306219

Received: 8 January 2011 Accepted: 10 March 2011.

Corresponding author's email: omagbogidi@yahoo.com

A study was conducted in 2010 to investigate the effects of crude oil contaminated soil on biomass accumulation in *Jatropha curcas* seedlings in Asaba, Delta State, Nigeria. Oil levels used were 0.0, 2.0, 4.0, 6.0, 8.0 and 10.0% w/w. The trial was arranged in a randomized complete block design with four replications and monitored for 12 weeks after transplanting. Results showed that contamination of soil with crude oil significantly reduced ($P \leq 0.05$) biomass accumulation when compared with seedlings grown in the uncontaminated subplots. A negative interaction was observed between the soil crude oil level and weight gained in *J. curcas* seedlings. For instance, while the fresh weight of seedlings grown in 0.0% w/w of oil was 3.0g, as low as 2.1g was recorded for seedling exposed to 10.0g w/w of the oil. This study has demonstrated that crude oil contamination of soil has a significant effect of reducing the biomass accumulation in the seedlings of *Jatropha curcas*.

Abstract

Keywords: Biomass accumulation, Contaminated soil, Crude oil, *Jatropha curcas* seedlings.

INTRODUCTION

Jatropha curcas commonly called physic nut is a bush or small tree (up to 5m high). The genus name *Jatropha* is derived from the Greek word *jatros* (doctor), *trophe* (food), which implies medicinal uses. The plant is planted as a hedge (living fence) by farmers all over the world because it is not browsed by animals (Sukarin *et al.*, 1987, Achten *et al.*, 2007).

The plant has thick glabrous branchlets and the leaves are arranged alternately. The branches contain whitish latex, which causes brown stains that are very difficult to remove (Wini *et al.*, 2006). Although, native to the Caribbean, *J. curcas* today, is cultivated in almost all tropical and subtropical countries including Africa and Asia as protection hedges around gardens and fields. Other uses of this plant include potential for biodiesel production. It improves rural development through the promotion of women (local soap production), poverty reduction (protecting crops and selling seeds, oil and soap), erosion control and energy supply for the household and stationary engines in the rural area (Tigere *et al.*, 2006). *J. curcas* also has a great potentiality in the rehabilitation of degraded land (Achten *et al.*, 2007; Kumar *et al.*, 2008). *J. curcas* is a drought resistant plant that has wide adaptability to varied climate and soils. With the reviewed interest in the extraction of biodiesel from *J. curcas* plant due mainly to the fact that oil (28-38%) from the plant is converted to biodiesel which could be used as a good substitute for fossil fuel, there is an increase in the establishment of both plantations and normal cultivation of this multipurpose plant species in the Niger Delta area where oil activities are predominant. Crude oil pollution is an inevitable consequence of oil exploration and exploitation activities both in oil producing and consuming areas due mainly to accidental discharge human error, sabotage, transportation, natural causes etc (Agbogidi, 2005). Although studies have been conducted on oil pollution effects on crop plants and tree species (Terge, 1984; Anoliefo and Vwioko, 1995; Agbogidi, 2003; Smith *et al.*, 2006; Agbogidi and Dolor, 2007; Bamidele *et al.*, 2007; Agbogidi, 2009a; Agbogidi, 2009b), there is paucity of documented information on the effects of crude oil on the performance of *J. curcas*. It is against this background that a study as this was embarked upon. The present study has the aim of investigating the effects of crude oil contamination of soil on the biomass accumulation in *Jatropha curcas*.

MATERIALS AND METHODS

The study was conducted in 2010 at latitude 6°14'N and longitude 6°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 afterwards, 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 12 weeks after trans planting (WAT). At the end of the trial, the plants were harvested and separated into

roots, stems and leaves. The various parts were weighed (Fresh weights) and then oven dried at 85°C for 22 hours following the procedure of Anon (1966) and Agbogidi and Eshegbeyi (2006) until a constant weight (Dry weight) was achieved. Data collected were subjected to analysis of variance (ANOVA) and the significant means were separated with the Duncan's multiple range tests using SAS (2005).

RESULTS AND DISCUSSION

The biomass yield of *J. curcas* seedling grown in the unpolluted soil (0.0%) significantly differed ($P \leq 0.05$) from the weights of seedlings grown in other treatments (Tables 1 and 2). The reduction in the weights is oil-concentration dependent i.e. the leaf, stem and root biomass decreased with an increase in crude oil level in soil. The results of the present study where a negative interaction existed between the soil crude oil content and biomass accumulation in *J. curcas* confirmed the reports of Agbogidi and Eshegbeyi (2006), Agbogidi *et al.*, (2007) and Agbogidi (2009c) who noted that as hydrocarbons from oil polluted soil accumulate in the chloroplasts 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 matter content. Various contaminants including crude oil, spent engine oil and heavy metals have been found to significantly affect the growth and performances of various plant species.

The yield of a crop is a complex trait affected by genetically controlled physiological components (Agbogidi *et al.*, 2006; Agbogidi, 2009c), crude oil contamination of soil has been reported to cause reduction in the germination, growth and their performance and even yield (Anoliefo *et al.*, 2006; Vwioko *et al.*, 2006; Agbogidi *et al.*, 2007). Oil contamination of soil has also been shown to limit normal diffusion processes thereby reducing the availability of the level of some nutrients in the soil (Agbogidi and Egbuchua, 2010). The unavailability of mineral nutrients in soils following crude oil application to soil has been reported to cause such harmful effects as leaf chlorosis, necrosis, growth stunting in shoots and roots thereby leading to a reduction in biomass accumulation.

The observed significant reduction in the biomass accumulation in *J. curcas* seedlings grown in soils with higher oil levels could be attributed to the adulterated soil, which could have caused nutrient immobilization as the oil could here create some conditions in the soil, which make some vital nutrients unavailable to plants. Similar case of nutrient immobilization in soils treated with petroleum hydrocarbons have been reported by Benka-Coker and Ekundayo (1995), Benka-Coker and Ekundayo (1997), Ekundayo and Obuekwe (1977) and Agbogidi and Ejemete (2005). Agbogidi (2009c) maintained that in most cases, a reduction in shoot growth is a direct result of a reduction in root growth as roots are important organs for the absorption and translocation of water and mineral nutrients. Similar reports have been made by Sharma *et al.*, (1989), Gill *et al.*, (1992), Bamidele and Agbogidi (2000). This study has demonstrated that crude oil contamination of soil has a highly significant effect of reducing the biomass accumulation in *Jatropha curcas* seedlings. This study has implication on sustainability of using *Jatropha curcas* as a biodiesel species.

Literature Cited

- Achten, W.W., Verchot, L., Franken, Y.J., Mathijs, E., Sighn, V.P., Aert, R. and Muys, B. 2008. *Jatropha* biodiesel production. *Bioenergy* 32 (12): 1063-1084.
- Agbogidi, O.M. and Eshegbeyi, O.F. (2006). Performance of *Dacryodes edulis* (Don. G. Lam H.J.) seeds and seedlings in a crude oil contaminated soil. *Journal of Sustainable Forestry* 22 (3/4): 1-14.

- Agbogidi, O.M. 2003. Response of *Azolla africana* Desv. and *Salvinia nymphaeella* Desv. to the water soluble fraction of Odidi well crude oil. *Journal of Science and Technology Research* 2(4): 76-80.
- Agbogidi, O.M. 2006. Effects of soil contaminated with crude oil on the growth and yield of maize (*Zea mays* L) in Delta State (Ph. D Thesis).
- Agbogidi, O.M. 2009a. Yield components of six cultivars of cowpea (*Vigna unguiculata* (L.) Walp) grown on soil contaminated with spent engine oil. *Acta Agronomica Nigeriana* 9 (1 and 2): 1-6
- Agbogidi, O. M. 2009b. Effects of soil contaminated soil with spent lubricating oil on the germination of *Gmelina arborea* (Roxb.) seeds. *African Journal of Natural Sciences* 2 (4): 11-14.
- Agbogidi, O.M. 2009c. Locational effect on the performance of maize (*Zea mays* L) in soils treated with crude oil. *African Journal of Environmental Pollution and Health* 7(1): 36-42
- Agbogidi, O.M. 2010. Screening six cultivars of cowpea (*Vigna unguiculata* (L) Walp) for adaptation to soil contaminated with spent engine oil. *Academic Arena* 2(4): 33-40.
- Agbogidi, O.M. and Ayelo, E. 2010. Germination of African oil bean (*Pentaclethra macrophylla*, Benth.) Seeds grown in crude oil polluted soil. In: Onyekwelu, J., Adekunle, V.A.J. and Oke, D.O. (eds.). Proceedings of the 2nd biennial national conference of the forests and forest products society held at the Federal University of Technology, Akure, Nigeria between 26th and 29th of April 2010. Pp 105-111.
- Agbogidi, O.M. and Dolor, D. E. 2007. An assessment of the growth of *Irvingia gabonensis* (Aubry-Lecomte Ex O' Rorte) Bail seedlings as influenced by crude oil contamination of soil. *Asian Journal of Plant Sciences* 2: 1287-1292.
- Agbogidi, O.M and Egbuchua, C.O. 2010. Heavy metal concentrations of soil contaminated with spent engine oil in Asaba, Delta State. *Acta Agronomica Nigeriana* 10(1): 65-69.
- Agbogidi, O.M. and Ejemete, O.R. 2005. An assessment of the effects of crude oil pollution on soil properties, germination and growth of *Gambaya albida* (L.). *Uniswa Research Journal of Agriculture, Science and Technology* 8 (2): 148-155.
- Agbogidi, O.M., Eruotor, P.G. and Akparobi, S.O. 2007. Effects of crude oil levels on the growth of maize (*Zea mays* L). *American Journal of Food Technology* 2(6): 529-535.
- Agbogidi, O. M. and Ofuoku, A.U. (2005). Response of sour sop (*Annona muricata* Linn.) to crude oil levels. *Journal of Sustainable Tropical Agricultural Research* 16: 98-102.
- Agbogidi, O.M., Okonta, B.C. and Dolor, D.E. 2005. Socio-economic and environmental impact of crude oil exploration and production on agricultural production: a case study of Edjeba and Kokori communities in Delta State of Nigeria. *Global Journal of Environmental Sciences* 4 (2): 171-176.
- Anoliefo, G. O and Vwioko, D. E. 1995. Effect of spent lubricating oil on the growth of *Capsicum annum* L. and *Lycopersicon esculentum* Miller. *Environmental Pollution* 88: 361-364.
- Anoliefo, G. O. and Edegbai, B. O. 2000. Effect of spent engine oil as a soil contaminant on the growth of two egg plant species, *Solanum melongena* L. and *S. incanum* L. *Journal of Agriculture, Forestry and Fisheries* 1:21-25.
- Anoliefo, G. O. and Vwioko, D. E. 2001. Tolerance of *Chromolaena odorata* (L) K. and R. grown in soil contaminated with spent lubricating oil. *Journal of Tropical Bioscience* 1(1): 20-24.
- Anoliefo, G. O., Isikhuemhen, O. and Ohimain, E. 2006. Sensitivity studies of the common bean (*Vigna unguiculata*) and maize (*Zea mays*) to different soil types from the crude oil drilling site at Kutchalli, Nigeria. *Journal of Soils and Sediments* 6 (1): 30-36.
- Anonymous 1966. International rules for seed testing association. Norway (ISTA) seed Service and Tech., No. 4.
- Aregheore, E.M., Becker, K. and Mallar, H.P. 2003. Detoxification of a toxic variety of *Jatropha curcas*. *South Pacific Journal of Natural Science* 21:50-56.

- Asaba Meteorological Station, 2010. National Meteorological Bulletin 2010 Lagos, Nigeria.
- Atuanya, E.I. 1987. Effect of waste engine oil pollution on physical and chemical properties of soil: a case study of waste contaminated Delta soil in Bendel State. *Nigerian Journal of Applied Sciences* 5: 155-176.
- Awe, A.B., Baiyewu, R.A., Fatade, B.O., Adeleke, T.O., Omidran, M.B and Salaudeen, G.T. 2010. Photochemical and antimicrobial evaluation of the leaves of *Jatropha curcas*. In: Onyekwelu, J., Adekunle, V.A.J. and Oke, D.O. (eds.). Proceedings of the 2nd biennial national conference of the forests and forest products society held at the Federal University of Technology, Akure, Nigeria between 26th and 29th of April 2010. Pp 445 – 449.
- Bamidele, J.F. and Agbogidi, O.M. 2000. Toxicity of Odidi petroleum oil and its water-soluble fraction on three aquatic macrophytes. *Nigerian Journal of Science and Environment* 2:113-121.
- Bamidele, J. F., Agbogidi, O.M., and Ohienbor, O.M. 2007. Phyto-toxic effects of gasoline on *Ischaemum rugosum* (Salisb): a wetland species. *American Journal of Plant Physiology* 2(4): 276-281.
- Benka-Coker, M. O. and Ekundayo, J. A. 1995. Effect of an oil spill on soil physicochemical properties of a spill site in the Niger Delta area of Nigeria. *Environmental Monitoring and Assessment* 36:93-104.
- Benka-Coker, M. O. and Ekundayo, J. A. 1997. Applicability of evaluating the ability of microbes isolated from an oil spill site to degrade oil. *Environmental Monitoring and Assessment* 45: 259 – 272.
- Biswas, S., Kaushik, N. and Srikanth, G. 2006. Biodiesel: technology and business opportunities an insight presented at the biodiesel conference towards energy independence – Focus on *Jatropha*. Rashtrapati Nilayam, Bolaram, India.
- De Jong, E. 1980. The effect of a crude oil spill on cereals. *Environmental Pollution* 22: 187-196.
- Ekundayo, E. O. and Obuekwe, C. A. 1997. Effects of oil spill on soil physico-chemical properties of a spill site in a typic paleudult of Midwestern Nigeria. *Environmental Monitoring and Assessment* 45:209-221.
- Forson, F.K., Oduro, E.K. and Hammond-Donkoh, E. 2004. Performance of *Jatropha* oil blends in a diesel engine. *Renewable Energy* 29:1135-1145.
- Gill, L.S., Nyawuame, H.G.K. and Ehikhametalor, A.O. 1992. Effect of crude oil on the growth and anatomical features of *Chromolaena odorata* L. *News Letter* 5: 46-50
- Henry, R. 2009. Plant resources for food, fuel and conservation. *Earthsacn*.
- Ige, P.O. Oyeleye, B., Awosusi, B.M. and Olaitan, A.O. 2010. Effect of fertilizers on shoot growth of juvenile stock of *Jatropha curcas* L. In: Onyekwelu, J., Adekunle, V.A.J. and Oke, D.O. (eds.). Proceedings of the 2nd biennial National Conference of the Forests and Forest Products Society held at the Federal University of Technology, Akure, Nigeria between 26th and 29th of April 2010. Pp 372-379.
- Jepsen, J.K., Henning, R.K. and Nyati, B. 2006. Generative propagation of *Jatropha curcas* L. on Kalahari sand. *Environment Africa, Zimbabwe*.
- Kumar, A., Ashwani, C.A. and Satyawati, S. 2008a. An evaluation of multipurpose oil seed crop for industrial uses (*Jatropha curcas* L.): a review. *Industrial Crops and Products* 1-8.
- Kumar, G.P., Yadav, S.K., Thawale, P.R., Singh, S.K. and Juwarka, A. A. 2008b. Growth of *Jatropha curcas* on heavy metal contaminated soil amended with industrial wastes and *Azotobacter*: a greenhouse study. *Bioresource Technology* 99:2078-2082.
- Kureel, R.S. 2006. Prospects and potentials of *Jatropha curcas* for biodiesel production. A paper presented at the Biodiesel conference Towards Energy Independence – Focus on *Jatropha*. Rashtrapati Nilayam, Bolaram, India.
- Makkar, H.P., Becker, K., Sporer, F. and Wink, M. 1997. Studies on nutritive potentials n toxic constituents of fiddert provenances of *Jatropha curcas*. *Journal of Agricultural of Food Chemistry* 45:3152-3157.

- Openshaw, K. 2000. A review of *Jatropha curcas*: an oil plant of unfulfilled promise. *Biomass and Bioenergy* 19:1-5.
- Onyema, M.C. Osuagwu, N.C. and Igbokwe, B.I. 2008. The development and use of biofuels as alternative energy sources: issues, prospects and challenges for Africa. In: Popoola, L., (ed.). Proceedings of the 32nd Annual Conference of the Forestry Association of Nigeria (FAN) held in Umuahia, Abia State, between 20th and 24th October, 2008. Pp 675 – 681.
- Sharma, O.K., Chandler, C, and Salami, C. 1980. Environmental pollution and leaf cuticular variation in Kudzu (*Pereria lobata* Willd). *Annals of Botany* 45: 77-80.
- Smith, M. J., Flowers, T. H., Duncan, H.J., and Alder, J. 2006. Effects of polycyclic hydrocarbons on germination and subsequent growth of grasses and legumes in freshly contaminated soil and soil with aged PAHs residues. *Environmental Pollution* 141:519-525.
- Statistical software (SAS) 2005. Hargen and enhanced SAS Inst. Inc. USA.
- Sukarin, W., Yamada, Y. and Sakaguchi, S. 1987. Characteristics of Physic nut, *Jatropha curcas* L.) as a new biomass crop in the tropics. *Japanese Agricultural Resources* 20 (4): 302 – 303.
- Terge, K. 1984. Effect of oil pollution in the germination and vegetative growth of five species of vascular plants. *Oil and Petroleum Journal* 2:25-30.
- Tigere, T.A., Gatsi, T.C., Mudita, I. I., Chikuvire, T.J., Thamangani, S. and Mavunganidze, Z. 2006. Potentials of *Jatropha curcas* in improving smallholder farmers' livelihoods in Zimbabwe: an explanatory study of Makosa ward, Mutoko District *Journal of Sustainable Development in Africa* 7:11-16.
- Vwioko, D.E. and Fashemi, D.S. 2005. Growth response of *Ricinus cummunis* L. (castor oil) in spent lubricating oil polluted soil. *Journal of Applied Sciences and Environmental Management* 9 (2): 73 – 79.
- Vwioko, D. E., Anoliefo, G. O. and Fashemi, S. D. 2006. Metal concentration in plant tissues of *Ricinus communis* L (Castor oil) grown in soil contaminated with spent lubricating soil. *Journal of Applied Environmental Management* 10 (3): 127 – 134.
- Wini, S.P., Osman, M., Emmanuel, D.S. and Sreedevi, T.K. 2006. Improved livelihoods and environmental protection through biodiesel plantations in Asia. *Asian Biotechnology and Development Review* 8(2): 11-29.

Tables

Table 1. Fresh weight (g/plant) of *Jatropha curcas* as affected by various levels of crude oil contamination of soil

Oil in soil % (w/w)	Plant Parts			
	Leaf	Stem	Root	Means
0.0	28.6	30.5	10.6	23.2a
2.0	24.3	27.8	9.0	20.3b
4.0	16.7	21.9	7.8	15.4c
6.0	9.8	12.3	3.3	8.4d
8.0	5.4	7.7	2.4	5.1e
10.0	3.2	4.2	1.8	3.0f
Means	14.66	17.4a	5.6c	

Means with different letters are significantly different at $P \leq 0.05$ here by Duncan's multiple range tests

Table 2. Dry biomass (g/plant) of *Jatropha curcas* as influenced by various levels of crude oil contamination of soil

Oil in soil % (w/w)	Plant Parts			
	Leaf	Stem	Root	Means
0.0	9.7	10.8	3.6	8.0a
2.0	9.2	10.6	3.0	7.6a
4.0	8.0	9.1	2.2	6.4b
6.0	5.3	7.3	1.4	4.6c
8.0	4.2	5.0	0.8	3.3d
10.0	3.1	2.9	0.4	2.1e
Means	6.5	7.6	1.9	5.3

Means with different letters are significantly different at $P \leq 0.05$ here by Duncan's multiple range tests