GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 11, NO. 4, SEPTEMBER 2005: 453 - 456
COPYRIGHT(C) BACHUDO SCIENCE CO. LTD. PRINTED IN NIGERIA. ISSN 1118- 0579

EFFECTS OF SOIL POLLUTION BY CRUDE OIL ON SEEDLING GROWTH OF *LEUCAENA LEUCOCEPHALA* (LAM) DE WITT

M. O. AGBOGIDI, U. F. NWEKE and O. F. ESHEGBEYI

(Received 10 February, 2005; Revision accepted 18 April, 2005)

ABSTRACT

Investigations were carried out on the effect of crude oil levels (0.00%, 2.19%, 4.38%, 6.58% and 8.77%) on seedling growth of *Leucaena leucocephala*. A negative relationship was observed between the seedling growth responses of this forest fruit tree species and the concentration of crude oil applied to the soil. Oil treatment of soil at higher levels of 6.58% and 8.77% adversely affected the performance of *L. leucacephala* in terms of plant height, leaf area, collar girth and dry weight yield. The present study indicates that soil pollution by crude oil has a highly significant effect on the seedling growth and development of *L. leucocephala*.

KEYWORDS: Crude oil, *Leucaena leucocephala*, seedling growth, soil pollution

INTRODUCTION

The increased prospection of crude oil in Nigeria has resulted in negative effect on land and other ecosystems (Stanley, 1990). The constant threats of oil spillage in oil producing areas and other parts of the country on farmlands, crop plants, forest tree species and other vegetation have been widely reported (Gbadegsin, 1997; Nwilo, 1998; Bamidele and Agbogidi, 2000; Ogri, 2001; Agbogidi, 2003).

Leucaena leucocephala (Lam.) de Wilt (lead tree, subabul) is an exotic tree, which combines good coppicing ability with excellent biomass productivity and foliage nitrogen yields (Kang *et al.*, 1984; Etukudo, 2000). The plant belongs to the family Leguminosae, subfamily mimosiodae. It s a fast growing species with quick vegetal cover of erosion sites (Kang *al.*, 1989; Keay, 1989; NRC, 1993; Etukudo, 2000). Etukudo (2000) further maintained that construction of contour ditches planted with *L. leucocephala* to control runoff also provides forage as they form good browse trees. *L. leucocephala* is used as fuel wood, fodder tree species, as wattles, poles, yam takes, soil conservation and green manure (Abbiw, 1990; Okafor *et al.*, 1996; Pearce *et al.*, 2003). *Leucaena leucocephala* occurs in the forest zone. *L. leucocephala* is also useful for enclosing and demarcating garden areas (NRC, 1994). The fruits are black in colour and they enclose brown coloured endocarp containing dark brown seeds. The plant furnishes important supplies of edible fruits to many people who do not grow agricultural crops. The fruits are also veritable sources of vitamins, irons, sugars, minerals, tannins, oils, flavours to diets and raw materials to some manufacturing industries including chocolate and beverages (Abbiw, 1990; Okafor *et al.*, 1996; Etukudo, 2000; Pearce *et al.*, 2003). Many of the plant components including the roots, leaves, and seeds are used for herbal preparations (Gill, 1992).

Although work has been done on oil pollution and some forest trees including *Dacryodes edulis* (Eshegbeyi, 2004) and *Gambaya albida* (Ejemete, 2005), experimental investigation into the effects of oil pollution on the growth of this multipurpose forest fruit species is lacking. The present project has been undertaken to evaluate the effects of crude oil applied at various concentrations on the growth and development of *Leucaena leucocephala* in Asaba, Delta State, Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted in the teaching and research farm of the Delta State University, Asaba Campus. Asaba (latitude 6° 14 ^{1}N, longitude 6° 49^{1}E, temperature 28±6°C, rainfall 1505mm, relative humidity 69-80% and sunshine 4.8 hours) is located in the rainfall agro-ecological zone (Asaba Meteorological Bulletin, 2003).

Source of fruits/seeds

Mature fruits of *L. leucocephala* were purchased from Ogbeogonogo market in Oshimili – South Local Government Area of Delta State. The seeds were mechanically extracted from the fruits. The seeds were subjected to pre-germination treatment following Ogbomo (1994) and Igbenije (2003). This involved softening of seeds with water temperature of 60°C. Viable seeds were sorted out by simple flotation technique. This involved the stepping of seeds into water in a beaker; the seeds that sunk to the bottom were used for planting.

Source of crude oil

The crude oil used (with specific gravity of 0.8768gcm^{-3}) was obtained from the Nigerian National Petroleum Corporation (NNPC), Warri, Delta State

Source of soil samples

The soil used was obtained from the *Gmelina arborea* plantation of the Department of Forestry and Wildlife, Faculty of Agriculture, Delta State University, Asaba Campus. The soil mixture used for the oil treatment was a 2:1 ratio of the topsoil to well decomposed organic manure. The mixture was air-dried and passed through 2mm sieve. The soil mixture 1.00kg (1,000g) set aside for each treatment was thoroughly mixed with the appropriate volume of crude oil before the polypots were each filled with 1.00kg weight of the oil contaminated soil. The concentrations of crude oil in the soil were 0.00 (control), 2.19%, 4.38%, 6.58% and 8.77% of oil per weight (% w/w) of soil respectively.

The experimental set-up thus consisted of five treatments; each consisted of 12 polypots with three replications. The experimental design adopted was a randomized complete block design. A seedling of *L. leucocephala* in the nursery was transplanted into the polypots at 12 weeks old and watered to field capacity immediately and afterwards, every other day until the end of the experiment following Egharevba and Osunde (2001). The set-up was monitored for 11 weeks after transplanting while parameters were measured fortnightly with effect from the third (3rd) week after transplanting. Plant height was measured with a meter rule at the distance from soil level to terminal bud. Leaf area was determined by tracing the leaf on a graph paper and the

M. O. AGBOGIDI, Faculty of Agriculture, Delta State University, Asaba Campus, Asaba, Delta State, Nigeria.
U. F. NWEKE, Faculty of Agriculture, Delta State University, Asaba Campus, Asaba, Delta State, Nigeria.
O. F. ESHEGBEYI, Faculty of Agriculture, Delta State University, Asaba Campus, Asaba, Delta State, Nigeria.

Table 1. Effects of crude oil pollution level on seedling growth (Plant height) of *Leucaena leucocephala*

Oil pollution level % (w/w)	plant height/ weeks after transplanting (WAT)					
	3	5	7	9	11	Means
0.00 (control)	30.52	32.43	33.92	35.67	36.85	33.87a
2.19	29.01	30.61	31.34	33.04	34.73	31.75b
4.38	25.63	26.15	26.84	27.48	27.85	26.79c
6.58	21.22	21.84	22.18	22.73	22.73	22.14d
8.77	19.56	19.92	20.11	20.11	20.11	19.96d

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

Table 2. Effects of crude oil pollution level on the leaf area (cm^2) of *Leucaena leucocephala*

Oil pollution level % (w/w)	leaf area/ WAT					
	3	5	7	9	11	Means
0.00	15.80	17.46	18.87	21.59	24.05	19.55a
2.19	15.62	17.38	18.52	20.98	23.84	19.27a
4.38	13.01	13.65	14.73	15.06	15.01	14.29b
6.58	12.84	12.89	13.40	14.63	17.60	13.67c
8.77	12.02	12.00	11.58	11.51	11.32	11.69d

Means with different superscripts are significantly different at P=0.05 level using DMRT.

Table 3. Effects of crude oil pollution level on the collar girth (cm) of *Leucaena leucocephala*

Oil pollution level % (w/w)	collar girth/ WAT					
	3	5	7	9	11	Means
0.00	0.40	1.15	1.24	1.50	1.73	1.20a
2.19	0.82	1.01	1.13	1.40	1.62	1.19a
4.38	0.80	0.83	0.87	0.94	1.00	0.89b
6.58	0.74	0.77	0.79	0.80	0.78	0.78c
8.77	0.71	0.74	0.74	0.71	0.70	0.72d

Means with different superscripts are significantly different at P=0.05 level using DMRT

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 trial (11 weeks), the plants were harvested and separated into leaves, stems and roots. They were oven-dried at 105°C for 18 hours following the procedure of Anonymous (1966) after which the dry weights were taken. Plant variables were analysed with Analysis of Variance (ANOVA) while the Duncan's multiple range test was used to evaluate statistical differences among each oil treatments (Sokal and Rohlf, 1980).

RESULTS AND DISCUSSION

As shown in Table 1, seedlings of *L. leucocephala* grown in the unpolluted soil had the highest plant height values throughout the experimental period. Seedlings grown in soil amended with 2.19% oil also had appreciable plant height values compared with seedlings subjected to 4.38%, 6.58% and 8.77%. No significant differences existed between *L. leucocephala* seedlings grown in soil treated with 6.58% and 8.77% of the oil. At the 9th and 11th weeks after transplanting (WAT) for seedlings grown in 6.58% of oil and as from the 7th WAT to the end of the trial for seedlings exposed to 8.77% of

Table 4. Effects of crude oil pollution level on the dry weight (g) yield of *Leucaena leucocephala*

oil pollution level % (w/w)	plant part			
	leaf	stem	root	Means
0.00	0.33	0.22	0.18	0.24a
2.19	0.30	0.20	0.16	0.22a
4.38	0.24	0.15	0.11	0.17b
6.58	0.13	0.10	0.06	0.10c
8.77	0.11	0.08	0.05	0.08c

Means with different superscripts are significantly diffe rent at P=0.05 level using DMRT.

oil, growth stunting and stagnancy were observed. The observed uninterrupted increase in plant height of *L. leucocephala* seedlings grown in the unpolluted soil could be interpreted as the unadulterated structure of the soil (control). The relative small amount of the oil (2.19% and 4.38%) in the soil could have been subjected to natural rehabilitation by oil degrading microbes thereby improving the fertility, physical and chemical properties of the soil, which could have manifested in the progressive increase in the plant height of seedlings grown in them. This observation is in line with the reports of Odu (1981). The reduced plant height of seedlings grown in soils treated with 6.58% and 877% of oil may be related to nutrient immobilization. Nutrient immobilization following crude oil poilution has been reported by De Jong (1980), Udo and Oputa (1984) and Siddiqui and Adams (2002).

The effects of crude oil pollution level on the leaf area of *L. leucocephala* are indicated in Table 2. The mean leaf area of seedlings grown in the unpolluted soil and that amended with 2.19% of the oil significantly differed from those subjected to soils amended with 4.38%, 6.58% and 8.77% levels of the oil at the 5% level of probability. The seedlings exposed to higher concentrations (6.58% and 8.77%) turned yellow, became necrotic and death occurred. Also evident in these seedlings were defoliation and leaf shedding. The observed reduction in the leaf area of *L. leucocephala* seedlings exposed to soils that received the higher concentrations may be due to increased effect of the oil, which could have inhibited cell enlargement, expansion, nutrient availability as well as other stress imposing properties of the crude oil. Reduction in leaf area also indicates that the leaf stomata were grossly affected by crude oil. This finding is in accordance with previous report of Gill *et al.* (1992).

Baker (1970b) reported that chronic pollution could eliminate whole vegetation. Baker (1970b) also maintained that oil spillage tends to cause drastic slow down in vegetation and recolonization of uncolonized habitats. Oil pollution has also been reported to have a direct herbicidal and phytotoxic effect on tree species (Bartha, 1977; Terge, 1984; Adegeye *et al.*, 1993; Overton, 1994). Reduced leaf area following oil pollution has been reported by Anoliefo and Vwioko (1994), Bamidele and Agbogidi (2000) and Agbogidi (2003). Reduced leaf area could reduce photosynthetic surface of the plant, which in turn can affect the growth and subsequent yield of the plant. The observed chlorosis and necrosis of *L. leucocephala* seedlings exposed to higher levels of oil may be due to chlorophyll destruction and cell injury. This finding conforms to prior findings of Baker (1970a), Ghouse *et al.* (1980), Sharma *et al.* (1980) and Smith *et al.* (1989) that oil affects photosynthesis and starch formation.

L. leucocephala seedlings grown in the control soil and soil amended with 2.19% of the crude oil had a progressive increase in collar girth throughout the experimental period. Significant reductions were however observed in the collar girth of seedlings exposed to higher levels (6.58% and 8.77%) compared with their counterparts in the control (Table 3). The observed negative relationship in the collar girth and the level of oil in the soil could have resulted in water stress imposed by crude oil pollution of the soil. This finding further confirms earlier report of Sharma *et al.* (1980).

A negative relationship was also observed in the dry matter yield of the *L. leucocephala* seedlings grown in soil amended with crude oil (Table 4). Since uptake of water and salts (ions) is carried out by the roots, it is possible that the unpolluted plants with roots undisturbed grow normally while seedlings that grew in the oil-polluted soils could have suffered some morphological and anatomical aberrations. Cell disruption in roots and other organs could have been eminent. This report corresponds with previous findings by Baker (1970b) and Siddiqui and Adams (2002).

CONCLUSION

Environmental pollution from crude oil has been shown to have adverse effects on plant growth and these may range from morphological aberrations, reduction in biomass and other abnormalities. The results of the present study have showed that pollution of soil with crude oil has a highly significant effect on the growth and development of *L. leucocephala* seedlings.

REFERENCES

Abbiw, D. K., 1990. Useful plants of Ghana: West Africa uses of wild and cultivated plants. Intermediate Technology publications and the Royal Botanical gardens, Kew

Adegeye, A. O., Ayodele, L. A. and Ufifio, L. A. , 1993. Effect of oil exploitation on the forest and wildlife resources in Delta State of Nigeria. *In:* E. A. Oduwaiye (ed.) Proceedings of the 23rd Annual Conference of the Forestry Association of Nigeria (FAN) held in Ikeja, Lagos State between 29th Nov. and 3rd Dec., 1993. Hedimo Press, Ibadan. Pp. 44 – 52.

Agbogidi, O. M., 2003. Response of *Azolla africana* Desv. and *Salvinia nymphellula* Desv. to the water soluble fraction of Odidi well crude oil. Journ. of Science and Technol. Research. 2 (4): 76-80

Anoliefo, G. and Vwioko, D. E., 1994. Effects of spent lubricating oil on the growth of *Capsicum annum* (L) and *Lycopersicon esculentum* (Miller). Environ. Pollut. 88:361-364

Anonymous, 1966. International rules for seed testing association, Norway (ISTA) Seed Service and Tech., No. 4.

Asaba Meteorological Bulletin, 2003. National meteorological report. *In:* Meteorological Bulletin, (2003), Lagos, Nigeria.

Baker, J. M., 1970a. The effects of oil on plants. Environ Pollut. 1: 27-44.

Baker, J. M., 1970b. The effects of oil plant physiology. *In:* Cowell, E. B. (ed). The ecological effect of oil pollution on littoral communities. Applied Sci. Publishers, London. Pp 88-98

Bamidele, J. F. and Agbogidi, O. M., 2000. Toxicity of odidi petroleum oil and its water-soluble fraction on three aquatic macrophytes. Nigerian Journ. Sci. Environ. 2:131-121.

Bartha, R., 1977. The effects of oil spill on trees. *J. Arboric* 3:142 – 47

De Jong, E., 1980. The effect of a crude oil spill on cereals. Environ. Pollut. 22:187-196

Egharevba, R.K. and Osunde, D.O., 2001. The effect of crude oil on seedling growth of two forest fruit trees: *Chrysophyllum albidum (Gambaya albida)* and *Dacryodes edulis G.Don*. Journ. Sustain. Agric. 18 (2/3): 25-35.

Ejemete,O. R., 2005. Performance of *Gambaya albida* (Linn.) seeds and seedlings in a crude oil contaminated soil. B. Forestry and Wildlife Project, Delta State University Asaba Campus.60p

Eshegbeyi, O. F., 2004. Performance of *Dacryodes edullis* (G.Don) seeds and seedlings in a crude oil contaminated soil. B. Forestry and Wildlife Project. Delta State University Asaba Campus.43p

Etukudo, I., 2000. Forests our divine treasure. Dorand Publishers. Uyo.

Gbadegsin, A ., 1997. The impact of oil exploration and production activities on the environment: implications for peasant agriculture *In:* F. Adewumi (ed.) and crisis in Nigeria's oil- bearing enclave. Emmi Press International, Ibadan. Pp 38-40.

Ghouse, A. K. M., Zaidi, S. H. and Atique, A. , 1980. Effect of pollution on the foliar organs of *Callistemon citrinus* Stap-F. Journ. of Sci. Resources, 2: 207-209.

Gill, L. S., 1992. Ethno medical uses of plants in Nigeria. Uniben Press, Benin-city

Gill, L.S., Nyawuame, H.G.K. and Ehihametelor, A.O., 1992. Effect of crude oil on the growth and anatomical features of *Chromolaena odorata* L. Newsletter , 5:46-50.

Igbenije, B., 2003. Effect of different temperature regimes on the germination and growth of *Dacryodes edulis* seeds. B. Agric. Project, Delta State University, 48p.

Kang, B.T., Vandar-Kruijs, A.C. and Cooper, D.C., 1989. Alley cropping for food production. In: B.T. Kang and L. Reynolds (eds.). Alley farming in the humid and sub-humid tropics, International Development Research Centre, Ottawa, Canada

National Research Council (NRC), 1993. Sustainable agriculture and the environment in the humid tropics. Washington, D.C. 702p.

NRC, 1994. *Leucaena:* promising forage and tree crop for the tropics. (2nd Ed.). National Academy Press, Washington D.C.100p

Nwilo, P. C., 1998. Spill: causes, impact and solution. In InfoTech today. Information management systems, Ltd, Lagos, Nigeria.

Odu, C. T., 1981. Degradation and weathering of crude oil under tropical conditions. Proceedings of seminar on petroleum industry and the Nigerian environment Federal Ministry of Works and Housing and NNPC, Kaduna.

Ogbomo, O.S., 1994. Effect of seed treatments on the germination of *Chrysophillum albidum*. B. Agric Project University of Benin, 45p.

Ogri, O. R., 2001. A review of the Nigeria petroleum industry and the associated environmental problems. The Environmentalist 21(1): 11-21.

Okafor, J. C., Ejiofor, M., and Okolo, H. C., 1996. Development and utilization of disappearing and under utilized edible woody forest species of southeastern Nigeria. Final technical report of project grant No. 7536. Biodiversity support programme, WWF, Washington DC.

Overton, E.B., Sharp, W. D. and Roberts, P., 1994. Toxicity of petroleum. *In*: L.G .Cockrham, (ed). Basic environmental toxicology. CRS Press, UK. Pp. 133-156.

Pearce, D., Putz, F. and Vanclay. J., 2003. Sustainable forestry in the tropics: panacea or folly? Forest Ecology and Management 172:2-3

Sharma, G. K., Chandler, C. and Salemi, L.., 1980. Environmental pollution and leaf cultivular variation in Kadzu (*Puereria lobata* Willd). Annals of Botany, 45:77-80.

Siddiqui, S. and Adams, W. A., 2002. The fate of diesel hydrocarbons in soils and their effect on the germination of perennial ryegrass. Environ. Toxicol. 17(1): 49-62.

Smith, B., Stachowisk, M. and Volkenburgh, E., 1989. Cellular processes limiting leaf growth in plants under hypoxic root stress. Journ. Exptal Botany, 40:89-94.

Sokal, R. R. and Rodlf. F. J., 1981. Biometry: the principles and practice of statistics in biological research. W.H. Freeman and Company, San Francisco.

Stanley, W. R., 1970. Socio-economic impact of oil in Nigeria. Geojournal 3:67-79.

Terge, K., 1984. Effect of oil pollution on germination and vegetative growth of five species of vascular plants. Oil Petrochemical. Pollut. 2: 25 – 30.

Udo, E. J. and Oputa, C. O., 1984. Some studies on the effect of crude oil pollution of soil on plant growth. J. Biol and App. Chem. 29: 3 – 14.