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

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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. leucocephala 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 prospect of crude oil in Nigeria has resulted in negative effect on land and other ecosystems (Stanley, 1990). The constant threat of oil spillage in oil producing areas and other parts of the country on farmlands, crop plants, forest tree species and other vegetation has been widely reported (Gbadea, 1997; Nwilo, 1998; Bambale and Agbogidi, 2000; Ogi, 2001; Agbogidi, 2003). Leucaena leucocephala (Lam.) de Witt (lead tree, subabul) is an exotic tree, which combines good coping ability with excellent biomass productivity and foliage nitrogen yields (Kang et al., 1984; Ekutudo, 2000). The plant belongs to the family Leguminosae, subfamily mimosaceae. It is a fast growing species with quick growth cover. of erosion sites (Kang et al., 1980; Keay, 1983; NRC, 1993; Ekutudo, 2000). Ekutudo (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 also useful for enclosing and demarcating garden areas (NRC, 1994). The fruits are black in colour and 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, iron, sugars, minerals, tannins, oils, flavours to diets and raw materials to some manufacturing industries including chicolates and beverages (Abbiw, 1990; Okafor et al., 1998; 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 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, iron, sugars, minerals, tannins, oils, flavours to diets and raw materials to some manufacturing industries including chicolates and beverages (Abbiw, 1990; Okafor et al., 1998; Pearce et al., 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 ebulu (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' N, longitude 6° 49'E, temperature 28.6°C, rainfall 1505mm, relative humidity 60-80% 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 Ogboogonoge market in Oshimili - South Local Government Area of Delta State. The fruits were mechanically extracted from the fruits. The seeds were subjected to pre-germination treatment following Ogboro (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 stopping 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 polybags were each filled with 1.00kg weight of the 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 polybags with three replications. The experimental design adopted was a randomized complete block design. A seeding of L. leucocephala in the nursery was transplanted into the polybags 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
Table 1. Effects of crude oil pollution level on seedling growth (Plant height) of Leucaena leucocephala

<table>
<thead>
<tr>
<th>Oil pollution level</th>
<th>plant height/ weeks after transplanting (WAT)</th>
<th>% (w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>0.00 (control)</td>
<td></td>
<td>30.52</td>
</tr>
<tr>
<td>2.19</td>
<td></td>
<td>29.01</td>
</tr>
<tr>
<td>4.38</td>
<td></td>
<td>25.63</td>
</tr>
<tr>
<td>6.58</td>
<td></td>
<td>21.22</td>
</tr>
<tr>
<td>8.77</td>
<td></td>
<td>19.56</td>
</tr>
</tbody>
</table>

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 (cm²) of Leucaena leucocephala

<table>
<thead>
<tr>
<th>Oil pollution level</th>
<th>leaf area/ WAT</th>
<th>% (w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>0.00</td>
<td></td>
<td>15.60</td>
</tr>
<tr>
<td>2.19</td>
<td></td>
<td>15.62</td>
</tr>
<tr>
<td>4.38</td>
<td></td>
<td>13.01</td>
</tr>
<tr>
<td>6.58</td>
<td></td>
<td>12.64</td>
</tr>
<tr>
<td>8.77</td>
<td></td>
<td>12.02</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Oil pollution level</th>
<th>collar girth/ WAT</th>
<th>% (w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>0.00</td>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td>2.19</td>
<td></td>
<td>0.82</td>
</tr>
<tr>
<td>4.38</td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td>6.58</td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>8.77</td>
<td></td>
<td>0.71</td>
</tr>
</tbody>
</table>

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

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 oil. At the 9th and 11th weeks after transplanting (9th 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*

<table>
<thead>
<tr>
<th>oil pollution level</th>
<th>leaf</th>
<th>stem</th>
<th>root</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.33</td>
<td>0.22</td>
<td>0.18</td>
<td>0.24a</td>
</tr>
<tr>
<td>2.19</td>
<td>0.30</td>
<td>0.20</td>
<td>0.16</td>
<td>0.22a</td>
</tr>
<tr>
<td>4.38</td>
<td>0.24</td>
<td>0.15</td>
<td>0.11</td>
<td>0.17b</td>
</tr>
<tr>
<td>6.58</td>
<td>0.13</td>
<td>0.10</td>
<td>0.06</td>
<td>0.10c</td>
</tr>
<tr>
<td>8.77</td>
<td>0.11</td>
<td>0.08</td>
<td>0.05</td>
<td>0.08c</td>
</tr>
</tbody>
</table>

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

oil, growth, stuntng and stagnancy were observed. The observed unimputed 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 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 8.77% of oil may be related to nutrient immobilization. Nutrient immobilization following crude oil pollution has been reported by De Jong (1980), Udo and Opia (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 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 uncultivated habitats. Oil pollution has also been reported to have a direct herbicidal and phytotoxic effect on tree species (Bartha, 1977; Terge, 1984; Adeyeye et al., 1993; Overton, 1994). Reduced leaf area following oil pollution has been reported by Anoliefo and Vwiko (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 soil oil may be due to chlorophyll destruction and cell injury. This finding conforms to the findings of Baker (1970a), Ghous 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


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