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Evaluation of the early growth performance *Bauhinia monandra*, *Delonix regia* and *Tetrapleura tetraptera* (Leguminous Tree Species) in crude oil-contaminated soil

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ABSTRACT

This study investigates the early growth performance of *Bauhinia monandra*, *Delonix regia* and *Tetrapleura tetraptera* (Leguminous Tree Species) (LTS) on crude oil-contaminated soil. It aimed to assess the growth performance of these LTS species in different levels of crude oil contamination (0, 25, 50, 75 and 100 ml in 4000 g soil; which represents the degree of light crude oil spillage concentration of 0.0, 0.63, 1.25, 1.88 and 2.5 %v/w respectively) on the growth performance. Seedling height, seedling girth and number of leaves were measured following standard protocols. The effectiveness of the 3 LTS for phytoremediation were in the order; *D. regia* > *B. monandra* > *T. tetraptera*. Results revealed percentage germination, seedling height, seedling girth and number of leaves decreased as the concentrations of crude oil in the soil samples increased at $P<0.05$. The tendency of the LTS plants under study suggests that they are promising for crude oil remediation in soil.

Keywords: Crude oil, Contamination, Leguminous trees, Phytoremediation, Soil *Bauhinia monandra*, *Delonix regia* and *Tetrapleura tetraptera*

INTRODUCTION

Crude oil spillage and its inherent soil contamination as a result of activities of the petroleum industry and pipelines sabotage is well reported as a frequent occurrence in the oil producing regions of the world, including Nigeria (Seiyaboh and Izah, 2017; Aigberua et al., 2017, 2016a,b; Izah *et al.*, 2017; Osuji and Onajake, 2004; Anoliefo *et al*., 2006a; Brandt *et al*., 2006; Nwaogu *et al*., 2006; Tanee and Kinako, 2008; Peng *et al*., 2009; Aroh *et al*., 2010; Osam *et al*., 2011a; Oyedeji *et al*., 2012). Conventional oil spill clean-up techniques involving physical and chemical processes can further damage soils and ecosystems (Frick *et al*., 1999).

Consequently, there is a need to develop an environmentally friendly technique that will not only degrade hydrocarbon contaminants in soil, but also restore terrestrial ecosystems.

Phytoremediation is an aspect of biological remediation (bioremediation) strategies that involves the use of living plants, soil amendments with associated microbes in plant root systems and agronomic practices for the removal, degradation, extraction and detoxification of contaminants (both organic and inorganic in soils, sediments, air and groundwater) (White *et al*., 2006). It is a non-destructive, cost-effective *in situ* technology that uses plants and their associated micro-organisms to clean up contaminated soils and it is, therefore, appropriate and useful in cleaning up contaminants from environmental systems (Nie *et al*., 2011). It has become a practicable solution for the remediation of petroleum hydrocarbon polluted sites (Tanee and Kinako, 2008; Liao *et al*., 2015), not only in developed countries, but also in developing nations with vast oil resources (Zand *et al*., 2010).

Earlier phytoremediation research (Chiapusio *et al*., 2007, Tanee and Kinako, 2008; Al-Awadhi *et al*., 2009; Njoku *et al*., 2009; John, *et al*., 2011; Ogbulie *et al*., 2011) focused on the use of leguminous herbs and shrubs, some of which are edible plant species with short growth life spans. However, to prevent inherent dangers of their use on health and food security in oil producing countries, the present study was based on the use of leguminous tree species (LTS).

Bauhinia monandra is a species of leguminous tree, of the sub-family Caesalpinoideae in the Fabaceae family. It is commonly known as the Orchid Tree or Napoleon's Plume. It grows naturally in Madagascar, but has naturalized in many tropical countries, including Nigeria. Nyananyo (2006) reported that *B. monandra* as the species occurring in the Niger Delta and rainforest region which is contiguous with the Niger Delta region. The plant is characterized by broad leaves, a flower with pink or white petals with one large anther, and a sharply elongated pod.

Delonix regia is a species of flowering plant in the family Fabaceae, sub-family Caesalpinioideae. This ornamental tree is commonly referred to as 'Flamboyant' or Flame of the Forest in Nigeria (Aigbokhan, 2014). The plant has fern-like leaves and a flamboyant display of flowers. *Delonix regia* is commonly propagated by seeds. *Delonix regia* is endemic to the western forests of Madagascar, it is very widely grown in the Caribbean, Africa and Northern Australia, but has been introduced into tropical and sub-tropical regions worldwide and occurs abundantly in the Niger Delta region of Nigeria (Nyananyo, 2006).

Tetrapleura tetraptera is a leguminous species of the sub-family Mimosoideae and family Fabaceae and it is endemic to tropical Africa and grows well in secondary forests (Keay *et al*., 1989; Omokhua and Ukoimah, 2008). It is commonly known as Aridan or Gum Tree and is native to southern Nigeria (Aigbokhan, 2014). It is a deciduous forest tree occurring on the fringe of the rain forest of the Niger Delta. It has compound leaves and attains a height of 20-25 m and girth of ≤1.5 m (Nyananyo, 2006).

Many leguminous plants have been studied for potential phytoremediation of crude oil contaminated environment. A previous study has assessed the germination rate of these three plants on crude oil contaminated soil (Oyedeji *et al.*, 2015a). Therefore, this study aimed at assessing the early growth response of *T. tetraptera, B. monandra* and *D. regia* for potential use as phytoremediation agents in crude oil contaminated soil.

Materials and Methods

Study site

The study was conducted in the greenhouse and postgraduate laboratories of the Department of Plant Science and Microbiology, Ekiti State University, Ado-Ekiti, Nigeria. The area is characterized by a tropical humid climate with two distinct seasons: a relatively cool wet season, which lasts from March-October (with a short dry season in July and August) and hot dry season between November-February. The area falls within the Nigerian forest zone where the rich tropical forests thrive. Ado-Ekiti has abundant rainfall (mean 1367 mm annually) with a mean daily temperature of 27ºC (Ademiluyi and Omotoso, 2008) and the town is >400 m above sea level. Kayode and Faluyi (1994) described the site soil as overlying metamorphic rocks of basement complex (utisol) which shows greater variation in grain size and mineral composition.

Experimental samples

(a). **Soil**: The sandy-loam topsoil used in the study was collected from a 4 year old fallow plot in the Research and Experimental Farm of Ekiti State University, Ado-Ekiti, Nigeria at 0-10 cm depth, according to Song *et al*. (1990).

(b). **Crude oil**: Bonny light type of crude oil was collected from Agip Petroleum Company, Omoku Flow Station, Omoku, Rivers State, Nigeria. The crude oil was used for the contamination of soil from the location of the study site, to simulate oil spill onto soil.

(c). **Selected Leguminous Tree Species (LTS) seeds investigated:**

(i). *Bauhinia monandra* seeds were obtained from forest vegetation at Ifon, Ondo State, Nigeria.

(ii). *Delonix regia* seeds were obtained from forest vegetation at Oporoma village, Bayelsa State, Nigeria.

(iii). *Tetrapleura tetraptera* seeds were obtained from vegetation at Uyo, Akwa-Ibom State, Nigeria.

Experimental design

This study involved greenhouse and field experiments. Three plant species were investigated viz: *Bauhinia monandra*, *Delonix regia* and *Tetrapleura tetraptera*.

Viability test of seeds and germination

The floating method, previously described by Anoliefo and Vwioko (1995), was used to determine the viability of LTS in this study. 500 seeds of each plant species were soaked in a water bath that contained distilled water for 30 minutes. The seeds that floated were discarded and 300 viable seeds were selected out of the seeds that sank. Plant germination was carried out based on the method previously described by Oyedeji et al. (2015a).

Greenhouse experiment: Establishment of selected tree species in crude oil-contaminated soil

Fifty (50) medium sized (2000 cm^3) plastic plant pots were filled with topsoil. Each planting pot with a uniform weight of 4000 g was arranged in the greenhouse. They were divided into five sub-groups. Each sub-group consisted of 10 pots, arranged in a row. The groups were contaminated with different concentrations (0.0, 0.63, 1.25, 1.88 and 2.5 %v/w) of light crude oil. All the treatments and control pots were watered with 500 ml distilled water for two weeks at an interval of 72 hours at 07:00 and one viable seed was sown in each of the pots in the treatments and its control two weeks after oil contamination.

Evaluation of the tree species agronomic parameters (plant height, girth and leaf number) was conducted every two weeks for 16 weeks. The seedling height was taken using a meter rule between the soil level and the last node towards the aerial part of the shoot. Seedling girth was determined at the first node above soil level with the aid of a Vernier caliper. The numbers of leaves produced by the seedlings growing in the control and oil-contaminated soil were physically counted. These parameters were similarly used by Vaitkutė *et al*. (2010) to determine tree growth.

Statistical Analysis

Data obtained from the experiments were analyzed using computer package SPSS, version 20 for Windows. All data were tested for homogeneity of variance, to determine their suitability for ANOVA tests before analysis. Data were also analyzed for least significant differences (LSD) within the treatments for each experiment separately. Correlation analysis (r) between contamination and plant growth was also determined.

RESULTS

The growth performance of the selected LTS in crude oil-contaminated soil was determined using the growth parameters: plant height, plant girth and number of leaves produced by the LTS during the 16-week period of study. Figure 1 shows the mean height of the selected LTS planted in crude oil-contaminated soils at 2 WAP. The mean height, girth and number of leaves observed in *D. regia* planted in non-contaminated soil were 7.72±6.11, 0.08±0.04 and 2.00±1.14 cm, respectively. *B. monandra* had a mean height of 0.76±1.70 cm and mean girth of 0.02±0.04 cm in the control experiment, but there was no growth in the treatments. The contaminated soil on which the LTS were planted may have delayed germination and growth. *T. tetraptera* recorded a mean height of 1.30±0.84, 1.20±0.76, 0.76±0.77, 0.24±0.54 and 0.00±0.00 in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. The mean girth was 0.08±0.04, 0.08±0.04, 0.06±0.05, 0.02±0.04 and 0.00±0.00 cm, respectively. Only *T. tetraptera* produced leaves in the contaminated soils at 2 WAP.

Figure 2 shows the growth performance of the LTS in crude oil-contaminated soil at 4 WAP. *D. regia* had a mean height of 22.30±6.58, 2.90±3.04, 1.46±2.02, 0.40±0.89 and 0.00±0.00 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. The mean girth was 0.16±0.05, 0.06±0.05 and 0.04±0.05 cm in treatments 0, 25 and 50 ml oil contaminated soils, but there was no visible plant girth in the 75 and 100 ml treatments. Two leaves were produced only in the control experiment. *B. monandra* had a mean height of 8.50±2.93 and 1.22±2.73 cm in 0 and 25 ml and a mean girth of 0.12±0.04 and 0.02±0.04 cm in 0 and 25 ml, but there was no growth in the 50, 75 and 100 ml treatments. *T. tetraptera* recorded a mean height of 2.46±0.48, 2.30±0.55, 1.86±0.57, 0.80±1.13 and 0.00±0.67 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. A mean girth of 0.10±0.00 cm was observed in the 0, 25 and 50 ml treatments. Only *T. tetraptera* produced leaves in both the un-contaminated and contaminated soils at 4 WAP. The selected plant species had low growth rates in the first 4 weeks after planting.

The growth performance of the selected LTS in crude oil-contaminated soil at 6 WAP is shown in Figure 3. *D. regia* had mean heights of 39.10±7.39, 15.82±8.50, 12.78±4.51, 5.52±4.93 and 4.02±0.74 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. Mean girths were 0.34±0.11, 0.16±0.05, 0.14±0.05, 0.08±0.00 and 0.01±0.00 cm in treatments 0, 25, 50, 75 and 100 ml oil contaminated soils, respectively. The number of leaves produced was 4.00±1.14, 3.00±1.17, 2.00±0.84, 1.00±0.50 and 1.00±0.00 leaves in the 0, 25, 50, 75 and 100 ml treatments, respectively. *B. monandra* had mean heights of 21.70±3.74, 10.00±4.31, 1.36±1.98, 0.66±1.01, 0.31±0.93 cm, with corresponding mean girths of 0.22±0.04, 0.12±0.04, 0.04±0.00, 0.04±0.05, 0.02±0.05 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. *B. monandra* produced 5.00±1.14 and 2.00±0.71 leaves in 0 and 25 ml crude oil contaminated soils respectively. *T. tetraptera* recorded mean height of 5.88±0.34, 4.84±0.55, 4.40±0.75, 3.08±1.19 and 2.98±1.08 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. Mean girth of 0.10±0.00 cm was observed in all the treatments. Only *T. tetraptera* produced leaves, 5, 4, 3 2 and 2 leaves in 0, 25, 50, 75 and 100 ml crude oil contaminated soils, respectively at 6 WAP.

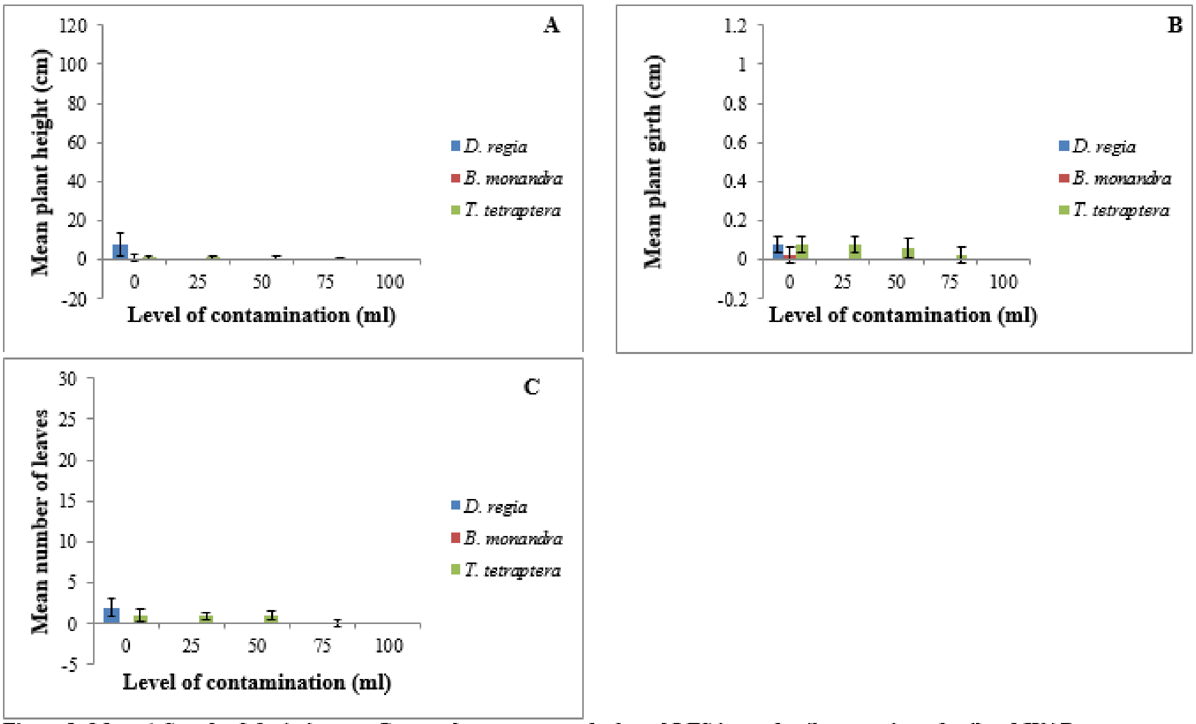

Figure 1: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 2 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

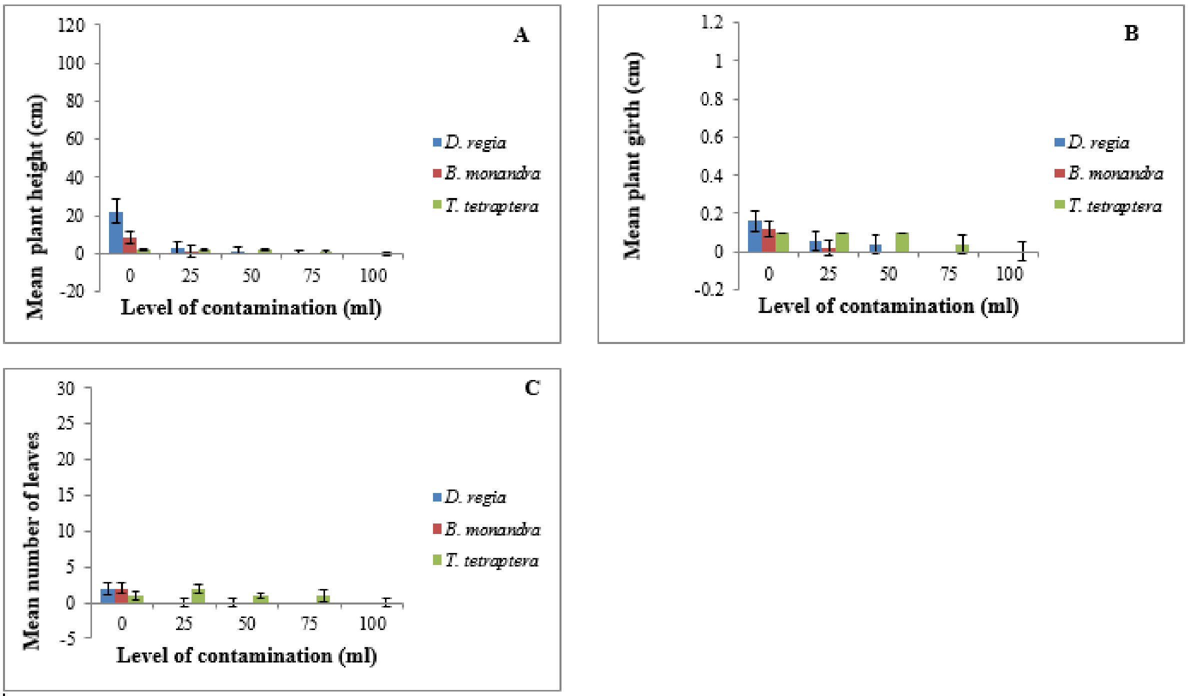

Figure 2: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 4 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

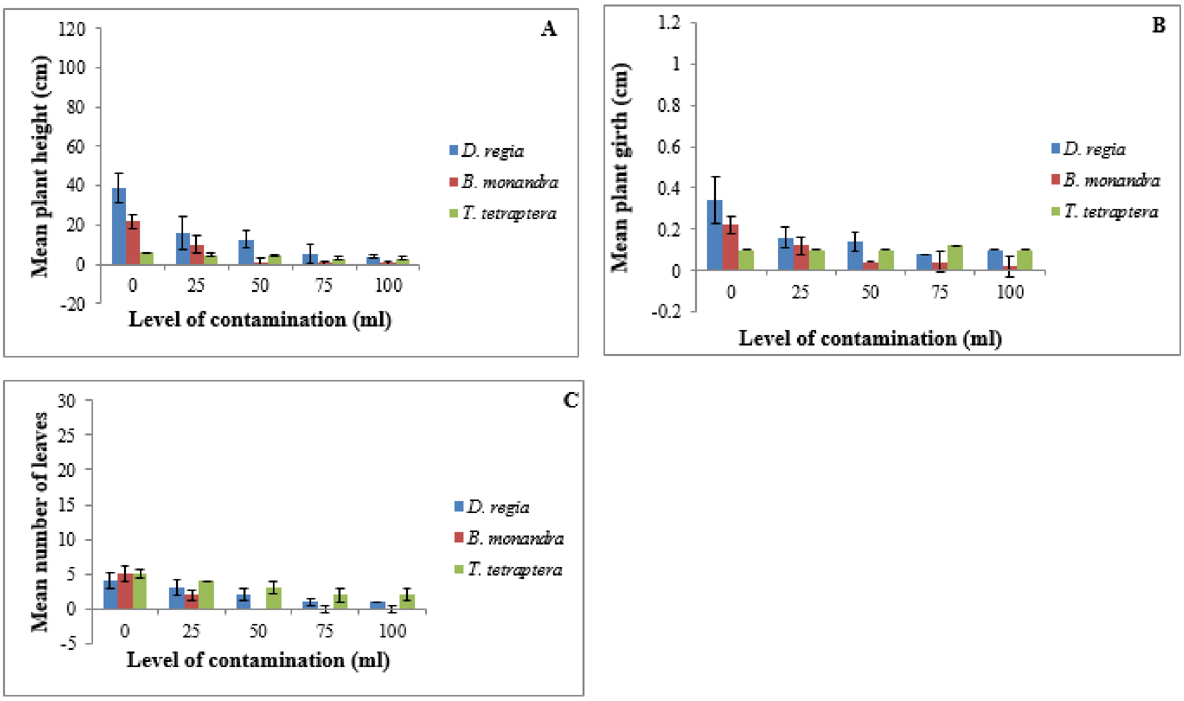

Figure 3: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 6 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

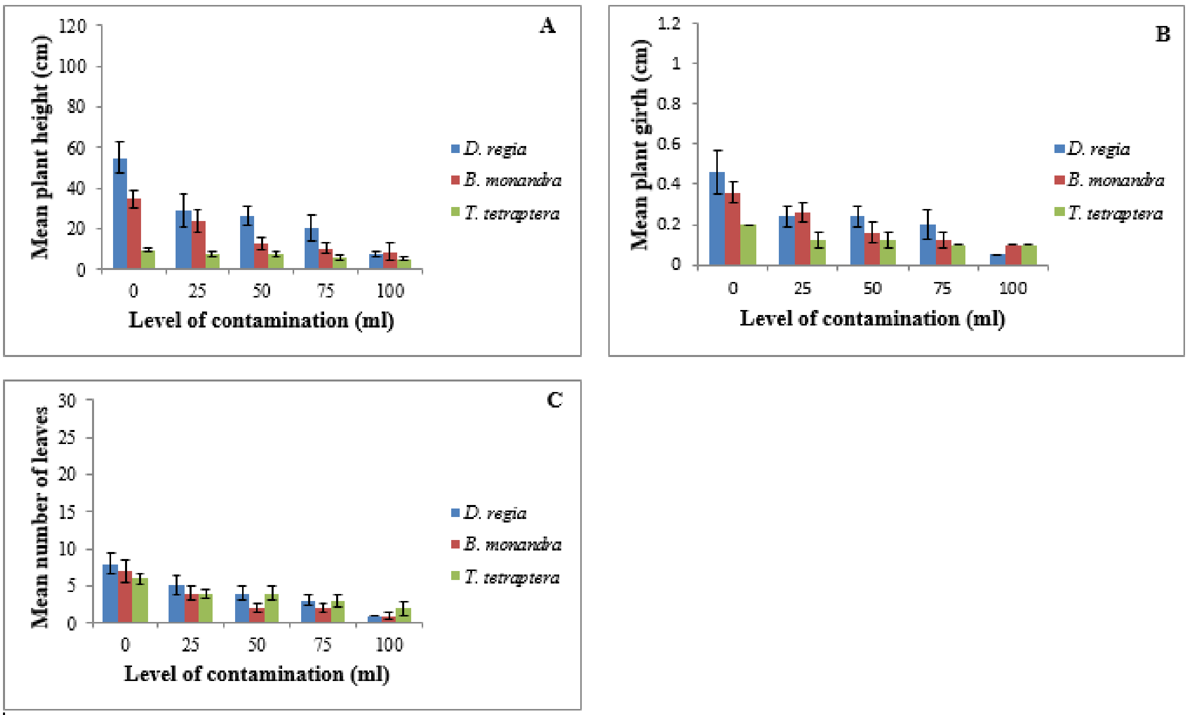

Figure 4: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 8 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

Figure 4 shows the mean growth performance of the selected LTS in crude oil-contaminated soil at 8 WAP. *D. regia* had mean plant height of 55.00±7.89, 28.94±8.07, 26.38±4.57, 20.32±6.47 and 7.69±1.15 cm. The mean plant girth was 0.46±0.11, 0.24±0.05, 0.24±0.05, 0.20±0.07 and 0.50±0.00 cm while

8.00±1.34, 5.00±1.30, 4.00±1.00, 3.00±0.71 and 1.00±0.00 mean number of leaves were produced in *D. regia* planted in 0, 25, 50, 75 and 100 ml crude oil contaminated soils. In *B. monandra*, mean plant height of 34.54±4.34, 23.80±5.75, 12.72±2.73, 10.44±2.31 and 8.82±4.35 cm were observed in 0, 25, 50, 75 and 100 ml crude oil contaminated soil respectively. The girths were 0.36±0.05, 0.26±0.05, 0.16±0.05, 0.12±0.04 and 0.10±0.00 cm respectively. The number of leaves produced by the tree species increased to Figure 5 shows the mean growth performance of the selected LTS in crude oil-contaminated soil at 10 WAP. *D. regia* mean plant height increased to 65.70±13.27, 41.08±11.86, 41.04±4.62, 32.86±5.76 and 25.36±1.88 cm. Mean girth also increased to 0.38±0.13, 0.38±0.13, 0.30±0.10, 0.28±0.08 and 0.20±0.00 cm. The mean number of leaves produced was 13.00±1.92, 9.00±3.67, 7.00±1.10, 5.00±1.34 and 4.00±0.45 in 0, 25, 50, 75 and 100 ml crude oil contaminated soils. *B. monandra* had mean plant height of 49.02±4.32, 39.24±4.17, 25.68±3.31, 23.46±3.38 and 20.72±4.67 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. Mean girths were 0.64±0.09, 0.42±0.04,

7.00±1.58, 4.00±1.00, 2.00±0.55, 2.00±0.55 and 1.00±0.45 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil respectively. *T. tetraptera* had mean plant height of 10.00±0.59, 7.48±1.37, 7.36±1.44, 6.18±1.35 and 5.28±0.68 cm. Mean girth were 0.20±0.00, 0.12±0.04, 0.12±0.04, 0.10±0.00 and 0.10±0.00 cm. It produced 6.00±0.71, 4.00±0.55, 4.00±0.89, 3.00±0.89 and 2.00±0.89 mean leaves in 0, 25, 50, 75 and 100 ml respectively.

0.32±0.14, 0.24±0.05 and 0.12 ±0.04 cm, respectively. The mean number of leaves produced by the tree species increased to 9.00±1.30, 6.00±0.84, 4.00±0.84, 3.00±0.55 and 3.00±0.55 in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. *T. tetraptera* had mean plant height of 13.04±0.63, 10.56±2.03, 10.40±0.29, 9.16±1.33 and 8.20±0.23 cm. Mean girths were 0.24±0.05, 0.20±0.07, 0.18±0.04, 0.12 ±0.04 and 0.10±0.00 cm. It produced 8.00±0.89, 5.00±1.58, 5.00±0.45, 3.00±1.00 and 3.00±0.55 mean number leaves in 0, 25, 50, 75 and 100 ml respectively. Thus, mean growth of LTS was related to the concentration of oil in soil and there was increased growth parameters as the experiment progressed.

The mean growth performance of the LTS in crude oil-contaminated soil at 12 WAP is presented in Figure 6. *D. regia* mean plant height increased to 84.12±8.31, 58.12±6.77, 51.76±4.90, 43.90±3.93 and 35.04±1.77 cm. Mean girth also increased to 0.78±0.08, 0.60±0.00, 0.46±0.05, 0.36±0.05 and 0.26±0.05 cm. The mean number of leaves was 17.00±1.67, 13.00±1.34, 9.00±1.30, 6.00±0.84 and 4.00±0.55 in 0, 25, 50, 75 and 100 ml crude oil contaminated soils. *B. monandra* had mean plant heights of 60.54±5.50, 51.60±4.67, 37.98±2.76, 33.84±3.54 and 30.48±3.83 cm in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. Mean girths were 0.70±0.14, 0.48±0.08,

0.24±0.13, 0.30±0.00 and 0.16±0.05 cm, respectively. Mean number of leaves produced by the trees increased to 10.00±1.79, 7.00±0.84, 4.00±0.89, 3.00±0.45 and 4.00±0.89 in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. *T. tetraptera* had mean plant heights of 15.64±0.83, 13.00±2.08, 13.26±0.62, 11.62±0.97 and 10.66±0.65 cm. Mean girths were 0.40±0.00, 0.20±0.05, 0.28±0.04, 0.20±0.00 and 0.16±0.05 cm. mean number of leaves were 8.00±0.45, 7.00±1.52, 6.00±0.71, 4.00±0.84 and 3.00±0.00 in 0, 25, 50, 75 and 100 ml, respectively. Thus, the mean growth of the trees was strongly influenced by concentration of oil in soil.

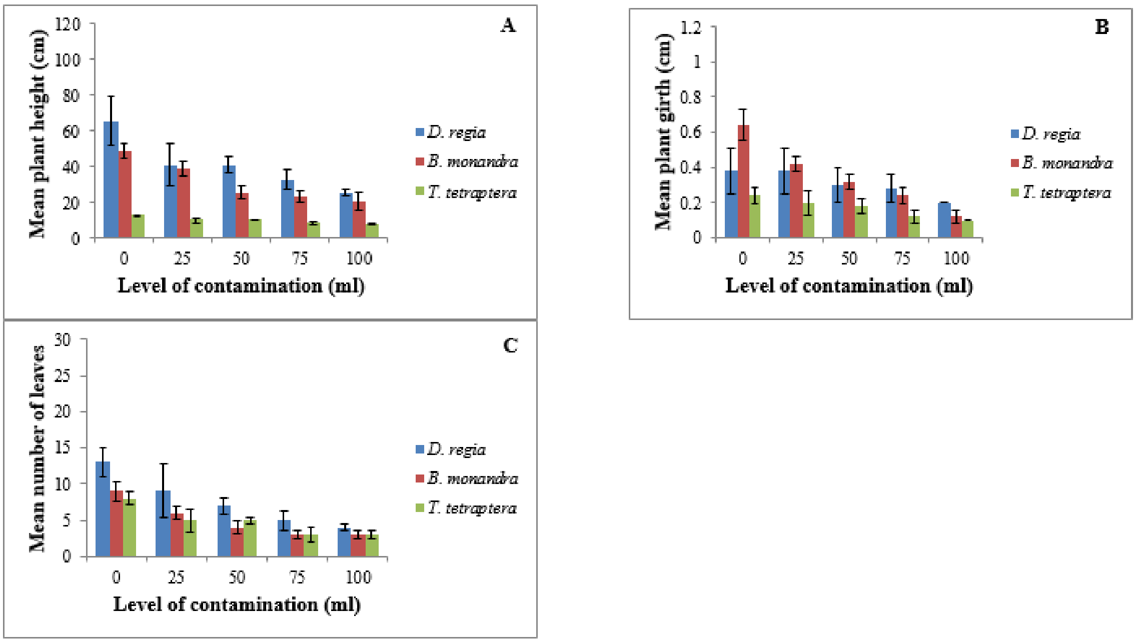

Figure 5: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 10 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

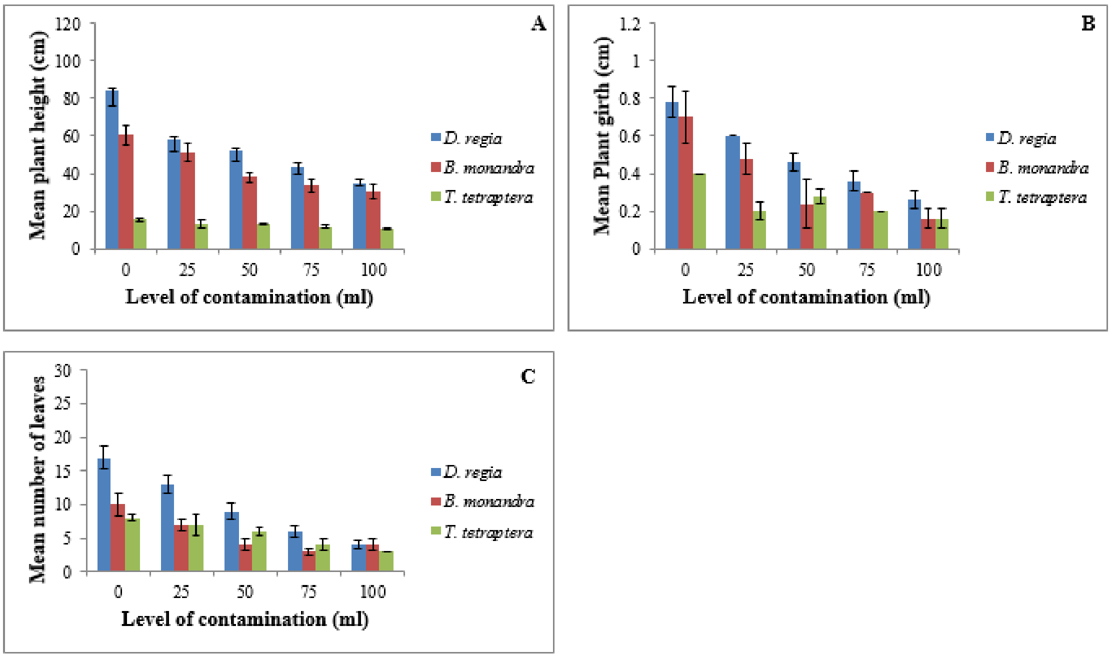

Figure 6: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 12 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

The mean growth performance of the selected LTS in crude oil-contaminated soil at 14 WAP is shown in Figure 7. The mean plant height of *D. regia* planted in crude oil contaminated soil was 98.40±13.16, 70.50±6.40, 64.62±5.04, 54.64±4.84 and 45.14±1.24 cm. Mean girth was 0.88±0.11, 0.74±0.05, 0.58±0.04, 0.44±0.09 and 0.30±0.00 cm, while the mean number of leaves produced was 18.00±2.45, 14.00±1.64, 11.00±2.41, 8.00±1.14 and 5.00±0.45 in 0, 25, 50, 75 and 100 ml crude oil contaminated soils. *B. monandra* had mean plant height of 75.90±3.67, 63.04±4.64, 49.66±4.02, 43.54±4.51 and 41.18±4.33 cm. The mean girths of the seedlings were 0.78±0.04, 0.60±0.07, 0.42±0.05, 0.38±0.08 and 0.30±0.10 cm, while the mean number of leaves increased to 12.00±1.30, 8.00±0.89, 5.00±0.45, 4.00±1.30 and 4.00±0.89 in 0, 25, 50, 75 and 100 ml crude oil contaminated soil respectively. *T. tetraptera* had mean plant height of 18.36±1.34, 15.38±1.97, 15.06±0.66, 13.64±1.06 and 11.94±0.40 cm. Mean girths were 0.38±0.04, 0.28±0.04, 0.30±0.00, 0.20±0.00 and 0.14±0.05 cm, while its leaf production increased to 8.00±1.10, 7.00±1.10, 6.00±1.14, 4.00±0.84 and 3.00±0.00 in 0, 25, 50, 75 and 100 ml, respectively.

The 16 WAP marked the end of the early growth study and the mean growth performance of the selected LTS is as shown in Figure 8. *D. regia* had mean height 114.20±10.34, 79.18±10.68, 78.90±4.84, 65.68±5.54 and 55.36±0.78 cm. Mean girths were 1.10±0.07, 0.72±0.13, 0.70±0.04, 0.56±0.09 and 0.44±0.04 cm, while the mean number of leaves was 23.00±1.73, 15.00±3.58, 13.00±1.87, 10.00±1.52 and 6.00±0.71 in 0, 25, 50, 75 and 100 ml crude oil contaminated soils. *B. monandra* had mean plant height 91.26±2.66, 74.58±4.44, 61.10±2.92, 53.88±3.90 and 51.32±4.78 cm. Mean girths were 0.88±0.04, 0.70±0.07, 0.54±0.05, 0.44±0.05 and 0.42±0.11 cm, while the mean number of leaves increased to 14.00±1.52, 9.00±0.89, 6.00±0.84, 6.00±0.89 and 4.00±0.89 in 0, 25, 50, 75 and 100 ml crude oil contaminated soil, respectively. *T. tetraptera* had a mean plant height of 21.16±0.97, 17.86±1.24, 16.80±0.62, 15.34±1.23 and 13.90±0.58 cm. Mean girth was 0.40±0.04, 0.34±0.05, 0.30±0.04, 0.20±0.04 and 0.16±0.05 cm, while leaf production increased to 9.00±0.55, 7.00±1.00, 7.00±0.84, 5.00±1.14 and 3.00±0.55 in 0, 25, 50, 75 and 100 ml, respectively. The overall results showed that the mean growth of the trees is related to the concentration of oil in soil and there continues to be an increase in the studied growth parameters with time.

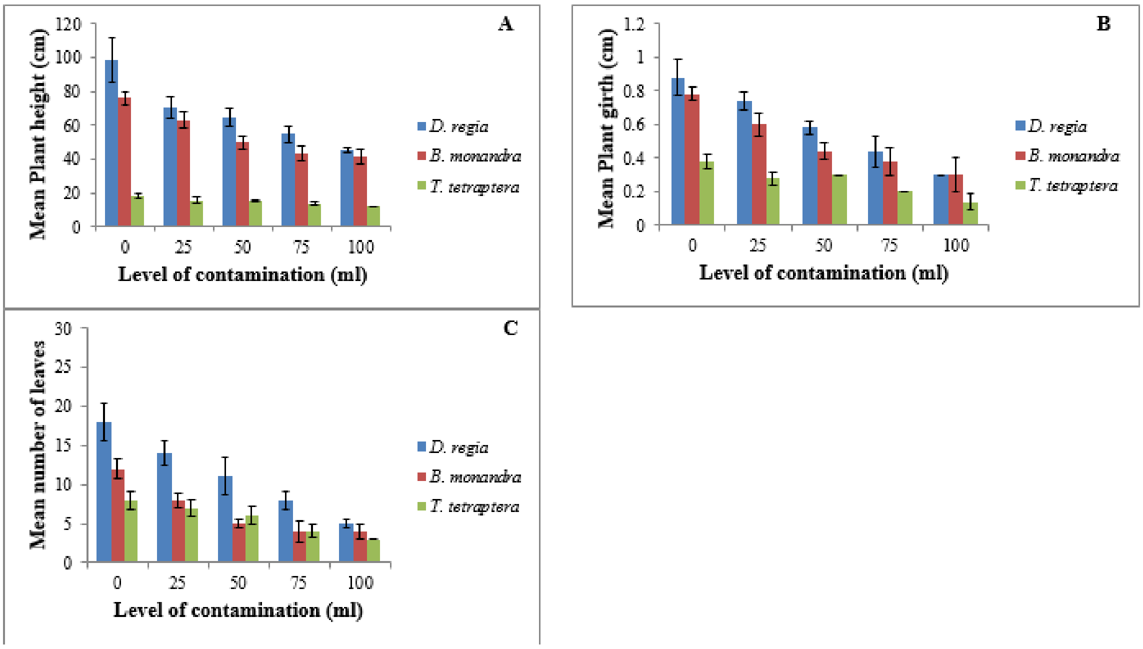

Figure 7: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminate soil at 14 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

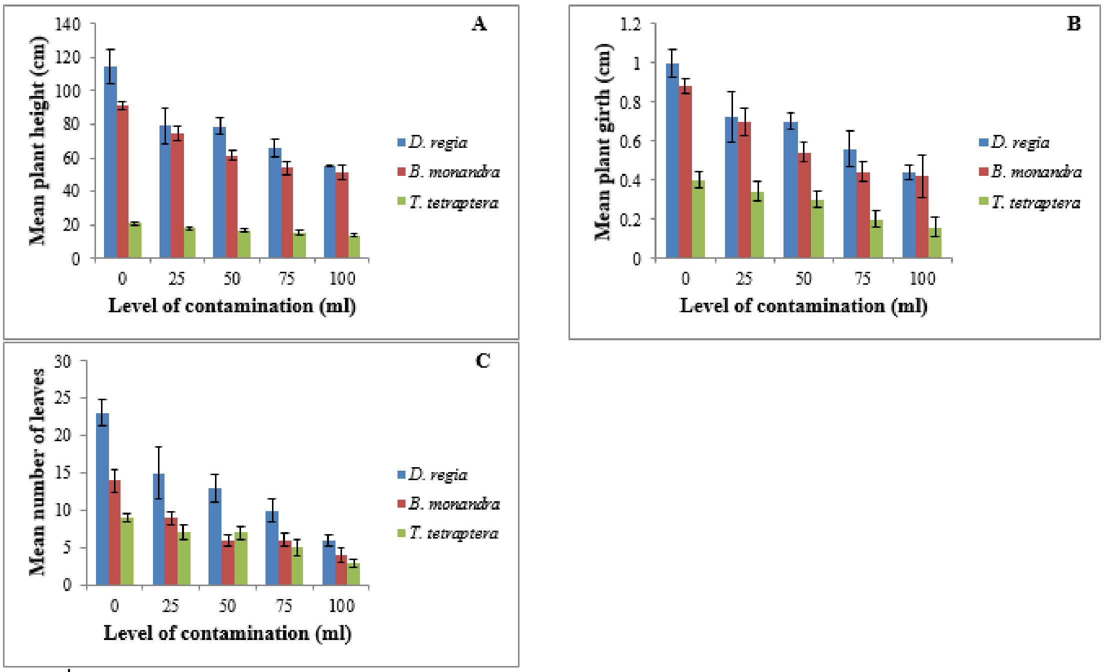

Figure 8: Mean (±Standard deviation, n = 5) growth parameters of selected LTS in crude oil-contaminated soil at 16 WAP. [(A) Mean plant height (B) Mean plant girth (C) Mean number of leaves].

One-way ANOVA and means separated by LSD at P <0.05 of growth parameters (height, girth and number of leaves) at 16 WAP revealed that the growth parameters of all species were significantly different (p<0.05) at the various levels of contamination from those grown in non-contaminated soil. Results from a Pearson correlation test between seedling heights, girths and leaf production among the 3 LTS under study are presented in Tables 1 – 3. For seedling height, the contaminants showed a strong negatively significant relationship with height of *D. regia*, *B. monandra* and *T. tetraptera* at P<0.01 (Table 1). This attests to its good germination reported in Table 1. Similarly, the treatments showed strong negatively significant relationships with girth of *D. regia*, *B. monandra* and *T. tetraptera* at P<0.01 (Table 2). The treatment also correlates negatively with leaf numbers of

D. regia, B. monandra and *T. tetraptera* at P<0.01 (Table 3). Furthermore, the height of the plants showed a positive significant relationship at P<0.01 with each other. This trend also occurred for the girths and number of leaves.

Table 1: Pearson Correlation analysis of mean seedling heights of leguminous tree species (LTS) at 16 WAP

LTS	Treatments	Height of *D. regia*	Height of *B. monandra*	Height of *T. tetraptera*
Treatments	1.0	-	-	-
Height of *D. regia*	-0.885**	1.0	-	-
Height of *B. monandra*	-0.936**	0.868**	1.0	-
Height of *T. tetraptera*	-0.921**	0.899**	0.927**	1.0

**Correlation is significant at P <0.01 (2-tailed).

Table 2: Pearson Correlation analysis of mean seedling girths of leguminous tree species (LTS) at 16 WAP

LTS	Treatments	Girth of *D. regia*	Girth of *B. monandra*	Girth of *T. tetraptera*
Treatments	1.0	-	-	-
Girth of *D. regia*	-0.898**	1.0	-	-
Girth of *B. monandra*	-0.905**	0.799**	1.0	-
Girth of *T. tetraptera*	-0.890**	0.841**	0.852**	1.0

**Correlation is significant at the 0.01 level (2-tailed).

Table 3: Pearson Correlation analysis of mean leaf production of leguminous tree species (LTS) at 16 WAP

LTS	Treatments	Number of Leaves of *D. regia*	Number of Leaves of *B. monandra*	Number of Leaves of *T. tetraptera*
Treatments	1.0	-	-	-
Number of Leaves *D. regia*	-0.930**	1.0	-	-
Number of Leaves *B. monandra*	-0.900**	0.874**	1.0	-
Number of Leaves *T. tetraptera*	-0.920**	0.849**	0.830**	1.0

**Correlation is significant at the 0.01 level (2-tailed).

DISCUSSIONS

Seedling height, girth and leaf production are important agronomic parameters used in the determination of plant health in the medium on which it is grown. Oil contamination of agricultural soils generally decreases plant growth and productivity (Anoliefo *et al*., 2006a; Kayode *et al*., 2009a; Zand *et al*., 2010); although, growth in some plants is possible with low levels of oil contamination (Amakiri and Onofeghara, 1983; Tesar *et al*., 2002; Osam *et al*., 2011a, Liao *et al*., 2015; Oyedeji *et al*., 2015a). However, the reasons for reduced plant growth are numerous and include inhibitory and direct toxic effects of oil on plants (Amadi *et al*., 1996; Kroening *et al*., 2001), lack of viable seeds (Rowell, 1977; Adkins *et al*., 2002), reduced germination arising from toxic soil conditions (Anolifo *et al*., 2001), low water uptake and reduced nutrient availability (Merkl *et al*., 2005a), osmotic stress and root gas exchange (Ko and Day, 2004; Merkl *et al*., 2005b; Robertson *et al*., 2007), poor soil aeration and porosity (Kayode *et al*., 2009b) and soil quality in terms of fertility (Neumann and Martinoi, 2002; Essien and John, 2010). Species with high germination success and subsequent tolerance and growth in oil-contaminated soil conditions are more suitable for phytoremediation as opined by Oyedeji *et al*. (2014) and Oyedeji *et al*. (2015b).

The adverse effects of oil contamination on plants have been reported (Isirimah *et al*., 1989; Kulakow *et al*., 2000; Tesar *et al*., 2002; Robson *et al*., 2003; Merkl *et al*., 2004b; Kayode and Oyedeji, 2012). At high concentrations of oil in soil, most species suffer remarkably decreased growth rates (Amakiri and Onofeghara, 1983; Anoliefo and Okoloko, 2000; Kayode *et al*., 2009a). Agronomic parameters were significantly different in the LTS when grown in crude oil-contaminated soils. However, some of the many selected LTS were able to tolerate the soil conditions and their growth was progressive during the study period, but growth (in terms of the studied growth parameters) of the LTS decreased with increased oil contamination in soil. However, some LTS seedlings showed adequate tolerance in crude oil-contaminated soils.

High oil concentrations in soil decreased seedlings height and this was in accord with Anoliefo and Okoloko (2000), Kayode *et al*. (2009a), Bamidele and Igiri (2011) and Liao *et al*. (2015). Our experimental results showed that seedling height of all species were significantly different at the various levels of contamination from those grown in non-contaminated soil. Correlation between seedling heights and contamination showed a strong negative correlation. Oil contamination stunts plants growth. These data support the assertions of Amakiri and Onofeghara (1983) and Liao *et al*. (2015) that the presence of oil in soil at high concentration decreases plant growth and stem girth. The presence of crude oil pollution decreased the number of leaves produced by the LTS seedlings. Seedlings grown on non-contaminated (control) soils produced significantly more leaves than those grown in oil-contaminated soils. The number of leaves of each species decreased as the concentration of crude oil in the soils increased. These accords with Ezeala (1987), who observed effects of crude oil pollution on leaf production in *Pistia stratoites*. However, in this study, *D. regia* had a higher leaf production over the other LTS tested by the end of the study, thus, further suggesting their potential to tolerate crude oil-contaminated soils and this further enhanced their suitability for phytoremediation and re-vegetation of crude oil-contaminated soil.

CONCLUSION

This study assessed early growth performance of *D. regia*, *B. monandra* and *T. tetraptera* grown in crude oil contaminated soil. Results showed that *D. regia* was associated with the greatest plant height and produced more seedlings and vegetative cover when grown on contaminated soil than either of the other LTS in the study. T and this suggests them as good candidates for phytoremediation. On the overall the effectiveness of the 3 LTS for phytoremediation were in the order; *D. regia* > *B. monandra* > *T. tetraptera*

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