Int. j. adv. multidisc. res. stud. 2024; 4(1):517-522

Received: 03-12-2023
Accepted: 13-01-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Effect of Crude Oil Contaminated Soil on Productivity and Harvest of *Mucuna Pruriens* (Var Cochinchinesis) Fabacea

[1] **Ogboeli Goodluck Prince,** [2] **Nwankwoala HO,** [3] **Ekineh Dorathy Richmond**
[1] Institue of Geoscience and Environmental Management, Rivers State University, Port Harcourt, Nigeria
[2] Department of Environmental/Applied Hydrogeology, Rivers State University, Port Harcourt, Nigeria
[3] Department of Science Education, Rivers State University, Port Harcourt, Nigeria

Corresponding Author: **Ogboeli Goodluck Prince**

Abstract
Consequences of various concentrations of crude oil on productivity and harvest of Velvet bean (*Mucuna pruriens*), were investigated, namely the effects of contaminated soil with 0ml, 100ml, 200ml, 400ml, 800ml, and 1600ml of crude oil were investigated. The findings showed that *M. pruriens'* root, shoot, seedling length, number of leaves, and nodules were all significantly (p 0.05) impacted by oil-contaminated soil. Additionally, the oil-contaminated soil had a significant (p0.05) impact on the fresh and dry weight of *M. pruriens* seedlings. Most of the growth parameters had mean values that were greater for the control soil and gradually fell for soils treated with 100 to 1600 milliliters of crude oil. With an increase in oil-contaminated soil concentrations, a significant decline in the seedling growth parameter of *M. pruriens* was seen. In general, the soil with the highest concentration of crude oil pollution showed a greater percentage of loss in most growth indices than the controlling comparison to garden soil treated as the control, leaf number and total seedling dry weight were significantly decreased in soil treated with 100ml, 200ml, 400ml, 800ml, and 1600ml of oil. With increasing concentrations of oil pollution treatment, *M. pruriens* seedling tolerance also reduced.

Keywords: Growth, Crude Oil, *Mucuna Pruriens* (Velvet Bean), Soil

Introduction

Legumes are plants that produce nitrogen-fixing nodules on their stems or roots in symbiotic relationship with the bacteria Rhizobium. Clovers, soybeans, peas, and beans are a few of them (Harrison, 2003). The Nigerian economy and environment have seen substantial changes as a result of the growth of the crude oil sector. The oil industry is a major contributor to environmental degradation, according to reports (Ibia *et al*., 2002; Ekpo and Thomas, 2007; Obaje, *et al*., 2020) [19, 15, 29]. Petroleum and its compounds are of special importance in pollution research because to their complex structural makeup, sluggish biodegradability, propensity for bio-magnification, and substantial health concerns connected with their discharge into the environment (Kathi and Khan, 2011) [22]. Additionally, during its transportation across the globe, oil is frequently spill damaging soil and water. The development of Gliricidia sepium and Azardirachta indica in used motor oil, a hydrocarbon waste of crude oil, is unsatisfactory because of the poor response of the soil, which results in the air being sucked out of the spaces between soil particles and the bacteria (Alamu, 2012). Numerous specialists have pointed out that farmland, trees, woods, and their seedlings are significantly impacted by oil spills (Udo and Fayemi, 1975 [38]; Bartha, 1977 [9]; Udo and Oputa, 1984; Ojimba, & Iyagba, 2012 [31]).

The amount of total soluble sugars, total soluble proteins, free amino acids, total chlorophyll and carotenoids, nucleic acids, and seed germination all significantly decreased in the leaves of Vigna mungo (L.) Hepper grown in oil-polluted soil as a result of the hydrocarbon's persistence. The persistence of hydrocarbons caused a significant decrease in seed germination (Ilangovan and Vivekanandan, 1992; Agbogidi, 2011 and SPDC 2019) [20, 2, 36]. The study of plant behavior in petroleum-contaminated soils enables the identification and selection of species that indicate oil contamination (Maranho *et al*., 2009) [24]. According to Ekpo *et al*. (2012) [16], varying doses of crude oil (20–80 ml) exhibited significant (p0.05) effects on the plant height, leaf length, area, and number of leaves of the soybean plant. Pollution of the environment retards the development rates of trees and shrubs, and it can even because entire forest stands to collapse. This could be mostly due to soil contamination, which is known to negatively affect the growth of root systems, especially in long-lived species like trees (Bojarczuk *et al*., 2002) [11]. Growing emissions from industry, transportation, auto-mechanic operations, and agriculture have resulted in trace metal pollution of soil and surface waterways, raising concerns about human health and environmental quality (Nwokol *et al*., 2012) [28]. Environmental pollution resulting from petroleum and its byproducts is the most pervasive issue. Global attention is being drawn to the release of crude oil into the environment through oil spills (Millioli, *et al*., 2009) [27]. With the continuous increase in environmental pollution and human disturbances of ecosystems, the study of plant responses to abiotic stress is more crucial than ever (Alkio, *et al*., 2005) [3]. Debojit (2006) [14] reported that there was evidence of the effects of crude oil contamination on productivity, species diversity, and soil temperature. The physical and chemical properties of soil have been demonstrated to be impacted by waste engine oil pollution (Atuanya, 1987; Ekundayo and Obuekwe, 1994; Benka-Coker and Ekundayo, 1995) [8, 17, 10]. Crude oil pollution has impacted the establishment of several plant species, including Zea mays, Abelmoschus esculentus, Capsifrutescens, Capsicum annum (L.), and Lycopersicon esculentum (Miller) (Amakitri and Onafeghara, 1983; Anoliefo and Vwioko, 1994) [4, 6]. The vegetation on our planet is an integral aspect of it. Plants have a vital role in the existence of all heterotrophic species, including the human population. Plants are most visibly used by us as food. More than 20,000 different species of edible plants are known to exist, yet over time, we have evolved to rely on less and fewer of these species for our nourishment (Králová and Másárovieová, 2006) [23]. Oil pollution is one of the major global issues. An important environmental problem is the direct effects of used lubricating oil disposal on plant development. The goal of the current study was to ascertain how soil contaminated by crude oil affected the productivity and harvest of Mucuna pruriens, a significant bean crop used for both grain and pasture.

Materials and Methods

The University of Port Harcourt's Plant Science and Biotechnology department's botanic garden served as the site of the investigation. The crude oil was obtained from the Aluu flow station of the Shell Petroleum Development Company of Nigeria Limited (SPDC), while the velvet bean seeds were obtained from the International Institute of Tropical Agriculture (IITA) in Ibadan, Oyo state, Nigeria. Then, 100% of the seeds that were checked for viability really grew. The planted bags were filled with thirty (30) kg of surface soil (0–15 cm) that was taken from the botanical garden of the University of Port Harcourt's department of Plant science and biotechnology. The study used a completely randomized design with 6 treatments, 8 replicates, and 45 observations. The therapies consist of: Treatment 1: The soil was not exposed to any pollutants (Control). Treatment 2 consists of 100 ml of PMS (Petrol), 200 ml of PMS (Petrol), 400 ml of PMS (Petrol), 800 ml of PMS (Petrol), and 1600 ml of PMS (Petrol). Except for the control, which was pollutant-free, the planted bags containing 30kg of soil were all polluted in one way or another. Five velvet bean seeds were planted, and after the pollutants had been in the soil for two weeks, they were thinned to one stand per bag. The soil's physico-chemical makeup and the velvet bean plants' morphology were both measured. The velvet bean plants' fresh and dry weights were measured at harvest (12 weeks after planting).

Result and Discussion

Table 1: Effects of vying concentration of crude oil contaminated soil on root, shoot, seedling length and number of leaves *Mucuna pruriens*

Treatments	Length (cm)			
	Root	Shoot	Plant size	No of leaves
Control	13.30	19.31	30.36	17.40
100ml	11.72	16.35	28.17	14.20
200ml	10.22	13.49	27.41	11.30
400ml	9.04	11.80	25.33	10.10
800ml	8.23	10.20	22.01	9.20
1600ml	6.90	7.40	17.11	7.10

Table 2: Effects of vying concentration of crude oil contaminated soil on seedling fresh weight (g) of *Mucuna pruriens*.

Treatments	Seedling fresh Weight (g)			
	Root	Shoot	Leaf	Seedling
Control	0.37	0.46	0.21	2.40
100ml	0.35	0.38	0.19	1.37
200ml	0.24	0.32	0.17	1.20
400ml	0.21	0.28	0.11	0.95
800ml	0.19	0.24	0.6	0.76
1600ml	0.09	0.21	0.2	0.42

Table 3: Effects of vying concentration of crude oil contaminateded soil on dry weight (g) of *Mucuna pruniens*

Treatments	Seedling dry Weight (g)				
	Root	Shoot	Leaf	Seedling	Nodules
Control	0.30	0.39	0.18	2.10	39.6
100ml	0.29	0.31	0.17	1.22	29.6
200ml	0.20	0.29	0.14	1.09	21.4
400ml	0.18	0.21	0.9	0.84	18.6
800ml	0.16	0.19	0.3	0.40	5.6
1600ml	0.04	0.17	0.1	0.12	1.8

Table 4: Percentage decrease or increase in seedling growth parameter and biomass production of *Mucuna pruriens* under different concentration

Growth parameters	Treatment					
	Control	100ml	200ml	400ml	800ml	1600ml
Seedling length	5.60	5.80	7.30	17.80	35.60	48.40
Root length	5.06	6.72	8.92	11.84	34.25	46.71
Shoot length	4.88	4.92	9.31	20.81	31.28	42.15
Number of leaves	16.25	17.15	21.57	23.40	29.11	35.24
Root fresh weight	72.54	77.02	71.22	60.44	52.45	36.47
Shoot fresh weight	20.22	25.44	21.04	19.70	17.22	16.77
Leaf fresh weight	84.78	89.37	81.76	76.42	60.33	54.02
Seedling fresh weight	67.24	71.56	68.29	66.03	59.27	51.04
Root dry weight	85.11	87.09	81.33	78.28	71.04	68.09
Shoot dry weight	37.22	41.90	36.43	23.67	21.33	19.89
Leaf dry weight	87.88	89.28	82.77	74.20	71.88	65.02
Seedling dry weight	64.37	68.20	65.32	60.24	47.89	42.80
Number of Nodules	39.6	29.6	21.4	18.6	5.6	1.8

Table 5: Percentage of tolerance in seedlings of *Mucuna pruriens* against different (100ml, 200mp, 400ml, 800ml and 1600ml) concentrations of crude oil polluted soil treatment

Tolerance indices (%)	Treatment					
	Control	**100ml**	**200ml**	**400ml**	**800ml**	**1600ml**
	100	96.84	91.24	84.44	76.05	67.22

As shown in Tables 1-5, the productivity and harvest performances of the velvet bean crop *Mucuna pruriens* were affected by various treatments (0ml, 100ml, 200ml, 400ml, 800ml, and 1600ml) of crude oil-contaminated soil. In comparison to the control, the crude oil-contaminated soil treatment substantially (p0.05) impacted root, shoot, seedling length, and number of leaves (Table 1). The control soil treatment had a high mean root, shoot, and seedling growth number of leaves of *Mucuna pruriens*. The values gotten for *M. pruriens*, root length (13.30 cm), shoot length (19.31 cm), seedling length (30.36 cm) and number of clears out (17.40) was most noteworthy in control soil. When exposed to 100ml of soil polluted with crude oil, the seedling length (30.36 cm), shoot length (19.31 cm), and number of leaves (17.40) all decreased dramatically. When treated with 200 cc of more crude oil-contaminated soil, *M. pruriens* seedling development was drastically reduced when compared to control. In comparison to control, the soils treated with 400ml of crude oil had further decreased means for seedling length (25.33 cm), root length (9.04 cm), shoot length (11.80 cm), and number of leaves (10.10). When treated with 1600ml of crude oil concentration, the mean values for seedling length (17.11 cm), shoot length (7.40 cm), and root length (6.90 cm) were determined to be the lowest. The link between the inhibitory effects of oil-polluted soil on fresh seedling weight of *M. pruri*ens and control soil treatment was determined to be significant (p 0.05). The effects of crude oil contaminated soil on the dry weight of the roots, shoots, leaves, seedlings, and nodules were also noted (Table 3). As compared to the control treatment, *M. pruriens'* root, shoot, seedling length, number of leaves, and dry weight reduced significantly at oil-polluted soil concentrations of 100 ml, 200 ml, 400 ml, 800 ml, and 1600 ml (Table 4). Oil-polluted soil treatment at a concentration of 100 ml was found to be responsible for a reduction in the root length (5.06%), shoot length (4.88%), and seedling length (5.60%) of *M. pruriens* when compared to control, while concentrations of 200 ml and 400 ml were found to be further responsible for a reduction in the seedling length, root length, number of leaves, and nodules of *M. pruriens*. Similar to this, it was shown that treatment of *M. pruriens* seedlings with soil contaminated with crude oil at concentrations ranging from 100ml to 1600ml caused a reduction in seedling fresh and dry weight compared to control.

The percentage of tolerance to treatment with oil-contaminated soil was also evaluated in *M. pruriens* seedlings. As compared to the control, the results demonstrated that *M. pruriens* seedlings had a high percentage of resistance to low concentrations of oil contaminated soil treatment (Table 5). Increased oil contamination of the soil reduced the tolerance indices in *M. pruriens* seedlings in comparison to control. According to the tolerance test, seedlings of *M. pruriens* displayed a high percentage of tolerance (96.84%) when exposed to soil contaminated with 100ml of crude oil as opposed to control soil treatment. In comparison to control soil treatment, the treatment of 200ml of crude oil-contaminated soil concentration resulted in a lower percentage of tolerance (91.24%) in seedlings of *M. pruriens*. Similar to this, *M. pruriens* seedling development displayed the lowest percentages of tolerance 84.44%, 76.05%, and 67.22% in 400ml, 800ml, and 1600ml treatments of soil polluted with crude oil.

Table 6: Analysis of variance of the effect of crude oil contaminated soil on Number of Nodules at different concentrations of crude oil

Source of variation	Degree of freedom	Sum of square	Mean square	F-Ration	F. Prob.
Blocks	4	2427.44	606.86	33.05	
Treatment	4	128.24	32.06	1.74	3.26
Variation	4	67.84	16.96	0.92	
Error	12	220.32	18.36		
Total	24	2843.84			

Table 7: Analysis of variance of the effect of crude oil contaminated soil on fresh and dried weight at different concentrations of crude oil

Source of variation	Degree of freedom	Sum of square	Mean square	F-Ration	F. Prob.
Blocks	4	35.63	8.90	8.10	
Treatment	4	2.92	0.73	0.68	3.26
Variation	4	18.05	4.51	4.10	
Error	12	13.18	1.09		
Total	24	69.80			

Fig 1: Week one after Germination count

Fig 2: Three weeks just before treatment

Fig 3: Three weeks after pollution

Fig 4: Five weeks after pollution

Fig 5: 0ml (control) of crude oil (After 5 weeks of pollution)

Fig 6: 800ml of crude oil (After 5 weeks of pollution)

Fig 7: 1600ml of crude oil (After 5 weeks of pollution)

Fig 8: 0ml of crude oil (After harvesting procedures)

Fig 9: 100ml of crude oil (After harvesting procedures)

Fig 10: 800ml of crude oil (After harvesting procedures)

Fig 11: 160ml of crude oil (After harvesting procedures)

Discussion

The findings of the current study revealed variation in *M. pruriens* seedling growth performance in oil-polluted soil. When compared to control soil treatment, the treatment of varied concentrations of oil-contaminated soil revealed a considerable variance in seedling length of *M. pruriens*. It appears that the hazardous pollutant present during the treatment of the oil-polluted soil was what caused the *M. pruriens* seedling length to decrease. Similar studies on the hazardous effects of used motor oil on Amaranthus hybridus L. biochemical characteristics, perennial rye grass germination, and maize growth performance have been published (Isirimah *et al*., 1989; Odjegba and Sadiq, 2002; Siddique and Adams, 2002) [21, 30, 37]. This study also showed that the performance of *M. pruriens'* shoot growth is significantly impacted by the application of crude oil at high soil concentrations. These results are consistent with other researchers' conclusions that crude oil contamination of soil has a detrimental impact on the development of plant species (Anoliefo, *et al*., 2003; Vwioko and Fashemi, 2005) [7, 39]. Abiotic stress is the cause of the *M. pruriens* seedling growth parameter's ongoing decline, according to this study. Increased crude oil pollution, which comprises a wide range of components including carbon, hydrogen, sulphur, nitrogen, and oxygen (Abb, 1997; Potter and Simmons, 1998; Maranho, *et al*., 2009) [1, 34, 24], may be a significant factor in the loss of *M. pruriens'* average shoot length. When exposed to various concentrations of crude oil pollution, *M. pruriens* produced fewer leaves than the control group; Anoliefo and Edegbai (2001) [5] observed a similar trend of declining leaf growth. These plants could be used as test organisms in analyzing the toxicity of this pollutant in soil and water, according to the negative effects of oil contamination on the reduction of total biomass and the length of the roots in Avena sativa L., Secale cereale L., and Hordeum vulgare L. (Petukhov *et al*., 2000) [32]. Podocarpus lambertii Klotzsch ex Endl. (Podocarpaceae) leaves were subjected to petroleum pollution in a different study by Maranho *et al*. (2006a) [26], which found that the variation in leaf anatomy was significantly correlated with pollution. The presence of crude oil in the soil makes it an undesirable habitat for *M. pruriens* to grow roots. Due to the establishment of improper growth conditions by oil pollution, larger levels of crude oil contamination (800 ml and 1600 ml) had an impact on *M. pruriens'* root growth performance. Oil pollution is extremely sensitive to plants. Because of poor soil aeration (Rowell, 1977) [35], oil in the soil adversely affects plant growth (De Jong, 1980) [13]. Due to many physical impacts, petroleum pollution hinders the growth of plants. According to Xu and Johnson (1995) [25], Hester and Mendelssohn (2000) [18], Pezeshki *et al*. (2000) [33], and other researchers, the main physical effect of the oil coating that covers the roots is its modification of water and nutrient uptake. Oil, according to Bona and Santos (2003) [12], reduces the soil's ability to retain water, which hinders plant growth. *M. pruriens* seedling biomass was least productive in soil samples that had been exposed to oil and most prolific in soil samples that had received control treatment. Similar trends of detrimental impacts on *M. pruriens* output were observed. The performance of *M. pruriens* seedlings can suffer as a result of physical and chemical alterations brought on by the addition of various levels of crude oil. The performance of *M. pruriens'* ability to produce biomass was reduced as a result of the hazardous pollutants from crude oil being present in the soil, which can be a significant factor in the decline in seedling growth.

Conclusion

According to the results of the current study, different concentrations of crude oil were treated with soil, which led to alterations in *M. pruriens* seedling growth performances in terms of seedling growth and biomass output. At 1600ml oil-contaminated soil treatment, there was a definite decrease in root, shoot, seedling length, nodule, and production compared to control. The notable alterations in *M. pruriens* seedling development performance when grown in crude oil-contaminated soil can be used as an effective pollutant indicator for monitoring crude oil pollution. Other plant species may also benefit from similar experiments to see whether they may be planted in oil-contaminated areas.

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