Available Online at http://www.journalajst.com

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol.06, Issue, 10, pp. 1865-1868, October, 2015

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

SCREENING OF *TELFAIRIA OCCIDENTALIS* HOOK IN CRUDE OIL CONTAMINATED SOIL AMENDED WITH GOAT DUNG USING PHYSIOLOGICAL INDICES

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ARTICLE INFO

Article History:
Received 09th July, 2015
Received in revised form
17th August, 2015
Accepted 29th September, 2015
Published online 17th October, 2015

Key words:

Telfairia occidentalis,
Crude Oil,
Contaminated Soil,
Goat dung,
Physiological Indices)

ABSTRACT

Selected physiological indices were used as screening tool in evaluating the response of Telfairia occidentalis Hook to crude oil polluted soil amended with goat dung. Pollution treatment was obtained by mixing two kilograms (2kg) of sandy-loam soil with 100ml of crude oil, alongside a control treatment- 0ml (unpolluted soil). The organic supplement was added at the rate of 0.5, 1.0, 1.5 and 2.0 kg to 100ml level of crude oil polluted soils and placed in perforated polythene bags. Three (3) seeds of T. occidentalis were maintained in each polythene bag based on treatment. Chemical properties of experimental soils were examined before and after harvest. There were significant ($P< 0.05$) reductions in phosphorus and nitrogen contents of contaminated soils relative to the control (unpolluted soil).The plant height, root length, leaf number and shoot/root ratio showed significant ($P < 0.05$) reductions in contaminated soils comparable with unpolluted treatment. Although, the crop growth parameters were improved with the application of goat dung, the values recorded were comparatively lower than those of the control (unpolluted soil). This study suggests that organic supplement such as goat dung has the potential of remediating the adverse effects of crude oil pollution by improving the soil physical and chemical properties as well as supplying the readily available nutrients for growth and development of the test crop.

INTRODUCTION

Telfairia occidentalis Hook, commonly called fluted pumpkin belongs to the family, Curcubitaceae (Grubben and Denton, 2004), and shows wide diversity in pod and seed colour, seed and plant vigour, anthocyanin content of leaves and petiole or shoots, etc (Chewya and Eyzauirre, 1999; Schippers, 2002). Fluted pumpkin grows best in warm humid tropics as a perennial but can be grown as an annual under limited rainfall (Grubben and Denton, 2004). Its leaves and immature seeds have lots of nutritive value, hence are cooked and consumed as vegetable while the rind and pulp of the fruits is used as fodder for livestock (Oderinde *et al*., 1990; Schippers, 2002; Grubben and Denton, 2004). In Nigeria, exploration and production of petroleum oil have been on the increase because of its increased demand as a source of energy and primary raw materials for chemical industries (Moeller *et al*., 2008; Etukudo *et al*., 2011). This increase in production, refining and transportation has brought with it an ever increasing problem of environmental pollution (Onuh *et al*., 2008; Ogbo, 2009). The Niger Delta region of Nigeria has been under the threat of petroleum oil pollution over the years (Inoni *et al*., 2006; Etukudo *et al*., 2015), and has been subjected to unsustainable oil exploration activities, thus rendering its ecosystem to a severely contaminated status (Adedokun and Ataga, 2013). The deleterious effect of petroleum oil pollution on the environment has generated a great necessity to protect the environment from this hazard (Moeller *et al*., 2008). The adverse effects of petroleum oil pollution include, damage to soil microorganisms and plants as well as distortion of soil chemistry, such as increase in soil organic carbon, and reduction in soil nitrate and phosphorus (Okolo *et al*., 2005; Etukudo *et al*., 2010). The use of organic manure is one of the economical and environmental friendly methods of remediation of adverse effects of oil pollution due to its macro and micro nutrients composition (Belay *et al*., 2001; Lei *et al*., 2005). Various remediation approaches have been reported, however, this study was designed to evaluate soil chemical properties and its relationship to selected physiological indices of *Telfairia occidentalis* Hook in crude oil contaminated soil.

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MATERIALS AND METHODS

Pollution Experiment

Sandy-loam soil obtained from Abak, Akwa Ibom State, Nigeria was analysed for physico-chemical properties using standard procedures (A.O.A.C, 1999).

Table 1. Chemical Properties of Experimental Soil before Harvest

Properties	Garden soil (control-0)	Pollution treatment	Remediation treatment- Concentration of Goat dung (kg)			
			0.5	1.0	1.5	2.0
pH	5.30 ± 0.62	5.40 ± 0.31	5.30 ± 0.20	5.42 ± 0.15	5.50 ±0.27	5.70 ± 0.23
Available P (mg/100g)	7.32 ± 0.43	0.19 ± 0.02	0.53 ± 0.04	1.56 ± 0.10	2.62 ± 0.18	2.76 ± 0.26
Total N (%)	1.66 ± 0.22	0.27 ± 0.05	0.10 ± 0.03	0.14 ± 0.02	0.17 ± 0.05	0.26 ± 0.42
Organic carbon (%)	2.08 ± 0.46	3.32 ± 0.50	3.42 ± 0.38	3.66 ± 0.34	4.07 ± 0.33	4.56 ± 0.24
Ca (mg/100g)	2.69 ± 0.24	2.80 ± 0.41	2.73 ± 0.46	2.96 ± 0.43	3.01 ± 0.21	3.37 ± 0.84
Mg (mg/100g)	2.12 ± 0.74	3.43 ± 0.82	2.20 ± 0.42	2.32 ± 0.27	2.46 ± 0.32	2.52 ± 0.22
Na (mg/100g)	3.20 ± 0.61	8.26 ± 0.34	3.46 ± 0.39	3.52 ± 0.33	3.67 ± 0.17	3.78 ± 0.40
K (mg/100g)	1.17 ± 0.52	1.34 ± 0.30	1.21 ± 0.30	1.25 ± 0.21	1.36 ± 0.22	1.49 ± 0.11

Mean ± standard error from five replicates

Table 2. Growth Parameters of *Telfairia occidentalis* Hook Grown in Crude Oil Polluted Soil Amended with Goat dung

Properties	Garden soil (control-0)	Pollution treatment	Remediation treatment- Concentration of Goat dung (kg)			
			0.5	1.0	1.5	2.0
Plant height (cm)	48.42 ± 0.29	14.25 ± 0.17	36.52 ± 0.47	37.27 ± 0.51	40.36 ± 0.70	42.24 ± 0.33
Root length (cm)	16.67 ± 0.35	10.30 ± 0.24	12.43 ± 0.40	11.36 ± 0.16	15.03 ± 0.82	15.23 ± 0.64
Leaf number	15.67 ± 0.62	6.33 ± 0.45	11.33 ± 0.32	11.37 ± 0.21	12.67 ± 0.54	12.93 ± 0.21
Shoot/Root ratio	3.09 ± 0.60	2.25 ± 0.20	3.22 ± 0.81	3.27 ± 0.42	3.17 ± 0.30	3.27 ± 0.42

Mean ± standard error from five replicates

Table 3. Chemical Properties of Experimental Soil after Harvest

Properties	Garden soil (control-0)	Pollution treatment	Remediation treatment- Concentration of Goat dung (kg)			
			0.5	1.0	1.5	2.0
pH	5.20 ± 0.21	4.30 ± 0.11	5.60 ± 0.20	5.60 ± 0.17	5.70 ±0.21	5.80 ± 0.26
Available P (mg/100g)	2.07 ± 0.34	0.03 ± 0.01	0.36 ± 0.06	0.41 ± 0.02	0.49 ± 0.08	0.57 ± 0.06
Total N (%)	0.42 ± 0.05	0.08 ± 0.02	0.03 ± 0.01	0.07 ± 0.02	0.10 ± 0.02	0.15 ± 0.02
Organic carbon (%)	0.33 ± 0.06	7.32 ± 0.43	3.72 ± 0.80	3.96 ± 0.30	4.52 ± 0.20	4.96 ± 0.19
Ca (mg/100g)	0.39 ± 0.04	1.75 ± 0.11	1.07 ± 0.41	1.12 ± 0.26	1.21 ± 0.35	1.90 ± 0.31
Mg (mg/100g)	1.03 ± 0.46	2.20 ± 0.21	0.97 ± 0.29	1.04 ± 0.43	1.09 ± 0.45	1.17 ± 0.36
Na (mg/100g)	1.96 ± 0.35	4.40 ± 0.47	1.76 ± 0.31	2.02 ± 0.13	2.36 ± 0.31	2.47 ± 0.12
K (mg/100g)	0.24 ± 0.02	1.16 ± 0.20	0.36 ± 0.03	0.52 ± 0.01	1.07 ± 0.27	1.16 ± 0.17

Mean ± standard error from five replicates

Two kilograms (2kg) of sandy-loam soil were mixed thoroughly with 100ml of crude oil and allowed to condition for one week, alongside a control treatment- 0ml (unpolluted soil).

Remediation Treatment

Goat dung was obtained from local farmers in Abak, Akwa Ibom State, Nigeria. The organic supplement was added at the rate of 0.5, 1.0, 1.5 and 2.0 kg to 100 ml level of crude oil polluted soils. The soil samples were allowed to condition for four weeks before being placed in perforated polythene bags (18 x 36cm).

Germination Studies

Seeds of *T. occidentalis* were obtained from Akwa Ibom State Agricultural Development Project (AKADEP), Uyo, Akwa Ibom State. Seeds were sterilized with 0.01% mercuric chloride solution for 30 seconds, washed several times with distilled water and air dried. Five (5) seeds of *T. occidentalis* were sown in each polythene bag based on treatment [0-control (soil only), pollution treatment (soil + 100ml crude oil), 0.5kg goat dung + 100ml crude oil + soil, 1.0kg goat dung + 100ml crude oil + soil, 1.5kg goat dung + 100ml crude oil + soil, and 2.0kg goat dung + 100ml crude oil + soil]. The seedlings were thinned to three (3) per bag. Five replicates were used for each treatment using randomized complete block design. The experimental set up was maintained at a mean minimum temperature of 22.32^{o}C and mean maximum temperature of 34.18^{o}C, under natural light condition for two (2) months.

Growth Studies

Plant height, root length, leaf number and shoot/root ratio were measured at the end of the experiment.

Statistical Analysis

Data analysis was carried out using analysis of variance (ANOVA) ($P < 0.05$) using the method of Ogbeibu (2005) and Obi (2002).

RESULTS

Table 1 shows the chemical properties of experimental soil before harvest. The pH of the experimental soils before harvest ranged from 5.30, 5.40, 5.30, 5.42, 5.50 to 5.70 in garden soil (control), pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of goat dung amended soil, respectively. The phosphorus content was comparatively lower in pollution treatment (0.19 mg/100g) than the control (7.32 mg/100g), while the phosphorus content in amended soils significantly ($P< 0.05$) increased with increase in levels of organic supplement with values ranging from 0.53, 1.56, 2.62 and 2.76 mg/100g for 0.5, 1.0, 1.5 and 2.0 kg level of organic amended soil, respectively (Table 1). The nitrogen content of the experimental soil ranged from 1.66, 0.27, 0.10, 0.14, 0.17 to 0.26 % for garden soil (control), pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of goat dung amended soil, respectively (Table 1). The carbon content of the experimental soil ranged from 2.08, 3.32, 3.42, 3.66, 4.07 to 4.56 for garden soil (control), pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of organic amendment, respectively (Table 1).

In addition, the calcium, magnesium, sodium and potassium contents were comparatively higher in pollution treatment (2.80, 3.43, 8.26 and 1.34 mg/100g) than the control (2.69, 2.12, 3.20 and 1.17 mg/100g).

Table 2 shows the growth parameters of *T. occidentalis.* The plant height of the crop significantly ($P< 0.05$) increased with increase in the level of goat dung, although these values were relatively lower than those of the control (Table 2). There were significant ($P < 0.05$) increases in root length of the test crop with application of goat dung above the value recorded at the pollution treatment. These values were comparatively lower than that of the control (Table 2). The leaf number of the crop ranged from 15.67, 6.33, 11.33, 11.37, 12.67 to 12.93 for control, pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of goat dung amended soil, respectively (Table 2). Similarly, the shoot/root ratio of the crop ranged from 3.09, 2.25, 3.22, 3.27, 3.17 to 3.27 for control, pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of goat dung amended soil, respectively (Table 2). Table 3 shows the chemical properties of experimental soil after harvest. The pH of the experimental soil ranges from 5.20, 4.30, 5.60, 5.60, 5.70 to 5.80 for control, pollution treatment, 0.5, 1.0, 1.5 and 2.0 kg level of goat dung amended soil, respectively (Table 3). Generally, a substantial proportion of chemical elements were present in the experimental soil at all levels of treatment after harvest (Table 3).

DISCUSSION

The chemical properties of experimental soil were negatively affected in pollution treatment. Petroleum oil pollution has been reported to alter both the chemical and physical properties of soils, aggregating soil particles, lowering porosity and increasing resistance to penetration and hydrophobicity (Onuhoha *et al*., 2003). In this study, the soil nitrogen and phosphorus level decreased considerably with increase in carbon contents in the polluted soil. This result is in line with the work of Okolo *et al*. (2005), Hussein (1997), and Etukudo *et al*. (2015) that crude oil pollution adversely affects the soil components due to adsorption to soil particles, increase in carbon that might be unavailable for microbial utilization and induction of a limitation in soil nitrogen and phosphorus. Similarly, the partial coating of soil surfaces by the hydrocarbons reduces the water –holding capacity of the soil due to a significant reduction in the binding properties of clay, thus, this partial coating also leads to reduced oxygen and water permeability through the soil (Chen *et al*., 1995; Adedokun and Ataga, 2007).

The adverse effects of petroleum oil pollution on pH might have contributed significantly to poor growth parameters of the test crop in pollution treatment as shown in this study. Soil pH directly affects solubility of many nutrients in soil for proper plant growth and development (Anoliefo, 2006; Udoh *et al*., 2005). However, the use of organic supplement ameliorated the unfavourable conditions in crude oil polluted soil by providing the available nutrients for plant use (Belay *et al.,* 2001; Odedina *et al*., 2003). In addition, the organic supplement has been shown to enhance biodegradation of petroleum pollutant by providing the favourable condition required by microorganisms for optimum biodegradation (Offor and Akonye, 2006). Similarly, the improved growth performance of the test crop may be attributed to the improved anaerobic and hydrostatic conditions of the polluted soil and enhanced soil-plant- water relationship resulting from the application of organic supplement (Moeller *et al*., 2008; Odokuma and Ibor, 2002).

Conclusion

This study suggests that organic supplement such as goat dung has the potential of remediating the adverse effects of crude oil pollution by improving the soil physical and chemical properties as well as supplying the readily available nutrients for growth and development of the test crop.

Conflict of interest

There was no conflict of interest among the three authors that contributed meaningfully to this research.

Acknowledgements

We wish to appreciate the contributions from Mr. Isaac Udo Isaac, the Senior Technologist, Department of Chemistry, and Mr Awolabi Akeem, Department of Biological Sciences, Faculty of Science, Federal University Otuoke, Bayelsa State. We also acknowledge all authors whose works have been cited as well as incorporated into the references of this paper.

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