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Response of Kenaf *(Hibiscus Cannabinus L.)* Grown in Different Soil Textures and Lead Concentrations

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Abstract: This study investigated effect of soil textures and Lead (Pb) concentrations on the growth, fibre yields and Pb absorption of kenaf. Screenhouse experiment was conducted in the University of Agriculture, Abeokuta (UNAAB) Ogun State, Nigeria. Top soils were collected from Murtala Victoria Botanical Garden, Epe, Lagos State, Nigeria and UNAAB Teaching and Research Farm. Ten-litre plastic pots were filled with 10kg soil. Experimental design was a 2 x 5 factorial in Randomized Complete Block Design replicated three times. Two soil textures and five levels of Pb concentration (as Lead nitrate): 0, 150, 300, 450 and 600 mgPb/kgsoil. Growth and yield parameters were collected. Lead levels in plant and soils were determined using Atomic Absorption Spectrophotometer. Data obtained were analysed using descriptive statistics and analysis of variance. UNAAB soil had pH of 6.3 and sandy loam texture while Epe soil had pH and texture of 5.3 and sand respectively. Control had significantly ($P<0.05$) higher stem girth, plant height, bast and core yields while 600mg/kg had the least in the two soils. Increased in the Pb concentration resulted in the increased in Pb absorption; Epe soil had better absorption of 89.87mg/kg than UNAAB soil with 78.17mg/kg.

Key words: Kenaf fibre; Kenaf lead absorption; Lead contaminated soils

INTRODUCTION

Soil lead contamination is one of the environmental problems facing the modern world. Sources of lead in soil include industrial activities such as mining and smelting processes, agricultural activities such as application of insecticide and municipal sewage sludges and urban activities such as use of lead in gasoline, paints and other materials [1]. Plants growing in a polluted environment can accumulate the toxic metals in high concentration causing serious risk to human health when consumed [2]. Several studies have shown that metals such as Lead (Pb), Cadmium (Cd), Nickel (Ni) amongst others are responsible for certain diseases that have lethal effects on man and animals [3,4,5]. Much research has been conducted on remediation of lead contaminated soil by employing conventional methods such as chemical, physical or biological treatment and significant progress has been made [6]. Conventional clean up technology is generally too costly and often harmful to desirable soil properties (texture and organic matter) when use in the restoration of contaminated soil [7]. Recently, increase attention has been given to the development of a plant based technology (Phytoremediation) to restore soil contaminated with metals. In the phytoremediation process, several sequential crops of selected plants species can be cultivated to reduce the concentration of heavy metal in contaminated soil to environmentally accepted level [8]. Metals in the soil can be translocated to above ground plant parts. The metal rich plant material may be safely harvested and removed from the site without extensive excavation, disposal cost and loss of top soil associated with traditional remediation practices [9]. For better land restoration or remediation, plant species used for the phytoremediation process must produce sufficient biomass while accumulating high concentration of the metal in question [7]. Kenaf (*Hibiscus cannabinus* L.) grow quickly, rising to height of 1.5 to 3.5m tall and the stems are 1-3cm diameter within 3-4 months and are generally known for its bast (outer) and core (inner) fibre [10]. Work has been done on the phytoremediation of metal contaminated soil using kenaf [11] but information on the effect of different soil textures and Pb concentrations in relation to absorption is limited and the attempt to bridge this gap formed the thrust of this study. The objective of this study was to determine effect of different soil textures and Pb concentrations on the growth, fibre yields and Pb absorption of Kenaf.

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MATERIALS AND METHODS

The screenhouse experiment was carried out in the University of Agriculture, Abeokuta, UNAAB (Latitude 7^0 9' N and longitude 30^0 21' E) Ogun State, Nigeria.

Soils sampling: Top soils (0-15cm) were colleted from Murtala Victoria Botanical Garden Epe, Lagos state (Latitude 6^0 59'N and Longitude 3^0 59'E) and UNAAB Teaching and Research Farm, the two locations are in the Southwestern part of Nigeria. The soils were thoroughly mixed by a mechanical mixer and passed through 4mm sieve to remove fibre and non soil particulate in the sample. The chemical and physical properties of the soils were determined prior to planting.

Soil preparation and planting: Ten-litre plastic pots were filled with 10kg soil that passed through a 4mm sieve. Experimental design was 2 x 5 factorial in Randomized Complete Block Design (RCBD) and replicated three times. The first factor was two soil textures (UNAAB and Epe) and the second factor was five lead levels (applied as Lead nitrate):0, 150, 300, 450 and 600 mgPb/kg soil. The soils in the pots were thoroughly mixed for even distribution of the contaminant and watered to field capacity. Three seeds of Kenaf (Cuba 108) were planted and thinned to one plant per pot two weeks after germination. 60 kgN/ha of N.P.K. (20:10:10) fertilizer was applied third week after planting and protected against insects by spraying with Nuvacron at sixth week after planting and continued at two weeks interval until 25% flowering (when harvested).

Data collection: Growth parameters such as plant height and stem girth were measured using metre rule and venier calliper respectively starting from sixth week after planting at two weeks intervals until harvest. Kenaf plants were harvested by cutting it from the soil surface ninety days after planting (at 25% flowering). Plant samples were oven dried at 80^0 for 48hours. Bast and core yields were determined by separating the outer (bast) from the inner (core) and weighed separately. Plant samples were then blended to fine particles and sub samples were taken from each pot after sieving with 2mm sieve for Pb determination. Soil from each pot was mixed thoroughly and sub samples were taken to know the Pb content of the soil after harvesting.

Laboratory analysis: Soil pH was determined using a glass electrode pH meter (Rent Model 720) in distilled water according to 12. Soil organic carbon was determined by the chromic acid digestion method of Walkley and Black as reported by 13. The total Nitrogen (N) concentration was determined by Macro-kjeldahl method according to 14, available Phosphorous (P) was determined by Bray-I method as described by 15. Exchangeable Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na) were extracted with neutral normal ammonium acetate buffer according to 16. Exchangeable K and Na were determined using Flame Photometer (Gallenkamp Model FH 500) and exchangeable Ca and Mg by Atomic Absorption Spectrophotometer (AAS). Pb content was determined by digesting one gram of the soil sample (< 2mm fraction) in 1:1 mixture of concentrated nitric and perchloric acids by heating the mixture plus sample over water bath in a fume cupboard. The solution was heated to dryness while the residue was re-dissolved in 5ml of 2.0M HCL as in 17. The mixture was finally filtered (Whatman No. 40). The resultant extracts were analysed for Pb using AAS [18].

From each ground plant sample, 2g was accurately weighed into clean platinum crucibles, ashed at 450^0C and then cooled to room temperature in a desiccator. The ash was completely dissolved in 5ml of 20% HCl which was then made up to volume in a 100ml volumetric flask [2]. Analysis of the digest for the Pb content was carried out using the AAS. The data collected were analysed using descriptive statistics and analysis of variance (ANOVA). Test of significance of the means was by the Least Significant Difference (LSD) and Duncan's Multiple Range (DMR) test.

RESULTS AND DISCUSSIONS

The soils chemical and physical properties prior to planting were shown in Table 1.The pH of the UNAAB soil was 1.0 unit higher than the pH of Epe soil and it represented slightly acidic soil while Epe soil represented strongly acidic soil [19]. The soils textures were sandy loam and sand for UNAAB and Epe soil respectively. The two soils were low in nutrient when compared to the nutrient ratings for soil fertility classes in Nigeria [20] but UNAAB soil was more fertile than Epe soil because it had higher organic matter, total N and available P. The Pb levels of the two soils were within the range (30-300mg/kg) of Pb in agricultural soil [2]. Figures 1 and 2 show the growth parameters in UNAAB and Epe soils respectively as affected by Pb concentrations from sixth Week After Planting (6WAP) to twelfth Week After Planting (12WAP). The stem girth and plant height increased from 6WAP to 12WAP at every concentration level. Control had significantly ($P<0.05$) higher stem girth and plant height than other treatments in the two soils. Table 2 shows the means bast and core yields in UNAAB and Epe soils. Significant decreased was

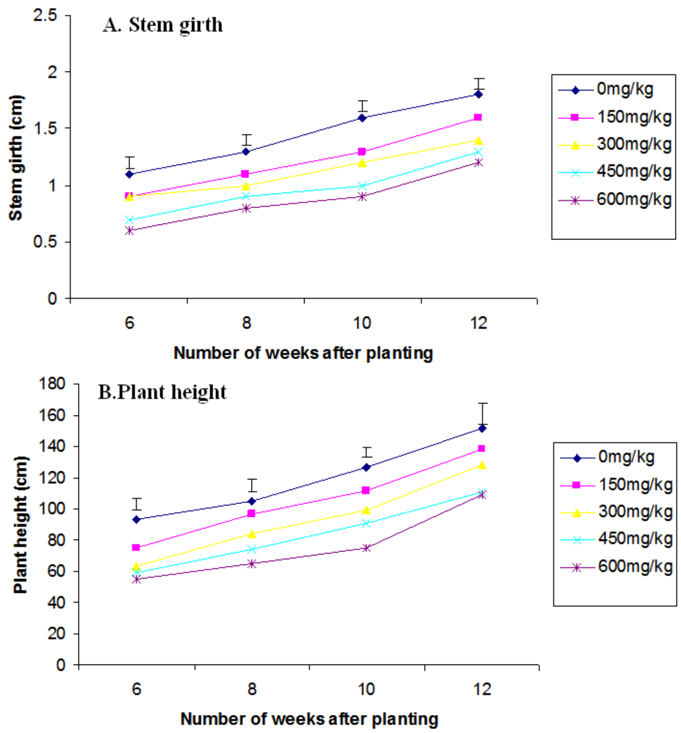

Fig. 1: Stem girth and plant height of kenaf as affected by lead concentrations in UNAAB soil.

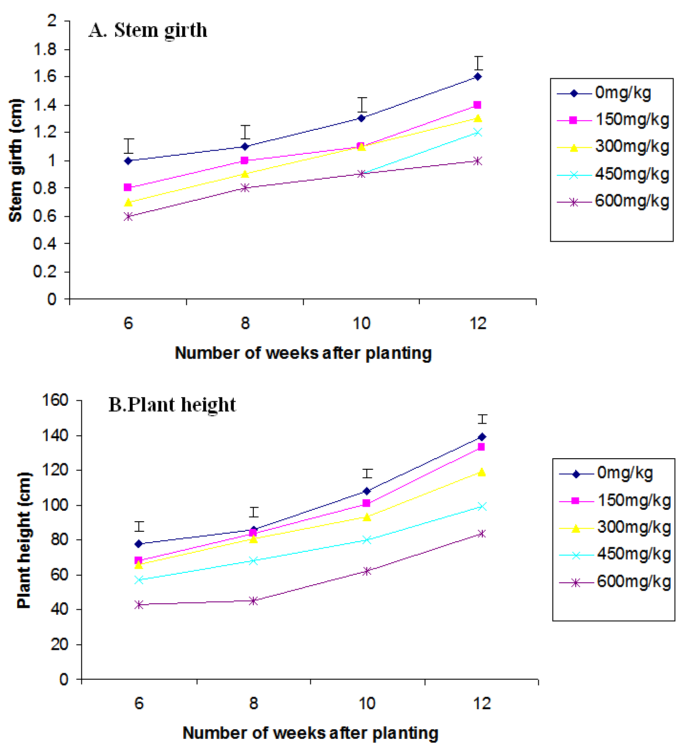

Fig. 2: Stem girth and plant height of kenaf as affected by lead concentrations in Epe soil

Table 1: Chemical and physical properties of UNAAB and Epe soils before Planting

Parameters	UNAAB soil	Epe soil
pH (H_2O)	6.30	5.30
Sand (g/kg)	755.00	918.00
Clay (g/kg)	75.00	11.00
Silt (g/kg)	170.00	71.00
Texture	Sandy loam	Sand
Exch. Ca (cmolkg^{-1})	1.38	1.32
Exch.Mg (cmolkg^{-1})	1.10	0.65
Exch.K (cmolkg^{-1})	0.18	0.13
Exch.Na (cmolkg^{-1})	0.12	0.85
Organic matter (g/kg)	16.30	12.20
Available P. (mg/kg)	7.50	6.20
Total N. (g/kg)	1.20	0.90
Lead (mg/kg)	10.00	35.50

Table 2: Effect of lead concentrations on bast and core yields of kenaf

Concentration (mg/kg)	UNAAB soil		Epe soil	
	Bast (g/pot)	Core (g/pot)	Bast (g/pot)	Core (g/pot)
0	11.30a	22.66a	9.191a	20.46a
150	10.07b	18.84b	4.204b	16.64b
300	8.96c	15.53c	3.723c	13.33c
450	8.50d	14.74d	3.590d	12.54d
600	7.08e	12.70e	1.998e	10.50e

Means in the same column followed by the same letter are not significantly different at P<0.05 according to DMRT

Table 3: Effect of lead concentrations on lead absorption by kenaf

Concentration (mg/kg)	UNAAB soil Pb absorption(mg/kg)	Epe soil Pb absorption (mg/kg)
0	5.26e	12.83e
150	48.25d	55.62d
300	55.51c	67.35c
450	63.58b	82.37b
600	78.17a	89.87a

Means in the same column followed by the same letter are not significantly different at P<0.05 according to DMRT

Table 4: Lead content of soils after harvesting

Concentration (mg/kg)	UNAAB Soil Pb content (mg/kg)	Epe soil Pb content (mg/kg)
0	3.8e	20.7e
150	85.2d	82.9d
300	214.7c	210.3c
450	371.3b	345.7b
600	469.4a	425.5a

Means in the same column followed by the same letter are not significantly different at P<0.05 according to DMRT observed in bast and core yields as concentration increased with control having significantly (P<0.05) highest bast and core yields while 600mg/kg had the least in the two soils and the decrease in bast and core yields was more in Epe soil than UNAAB soil when compared. The reduction in bast and core yields as concentration increased might be due to the quantity of Pb present in the soils which is not essential for plant growth. Effect of Pb concentrations on Pb absorption by kenaf was shown in Table 3. Increased in Pb concentration resulted in the increased in the absorption of Pb. Control and 600mg/kg had significantly (P<0.05) lowest and highest absorption respectively in the two soils with Epe soil had better absorption than UNAAB soil. This might probably due to the soil texture and the amount of metal in the soil. 21 and 22 reported that phytoextraction and uptake of heavy metal is enhanced by its availability and concentration in the soil. The difference in absorption of the two soils might probably due to the difference in their pH (Epe soil: 5.3 and UNAAB soil: 6.3). 22 reported that metal uptake by plant decreased as the pH of the soil increased due to the mobility and bioavailability of metals at lower soil pH. After harvesting, the residual Pb levels in the soils were presented in Table 4. The higher the concentration of Pb applied to the soils, the higher the residual concentration of Pb in the soils after harvesting and Pb content in the soils were lowered than the applied Pb concentrations. This observation supports the early report by 11 about the effectiveness of Kenaf to clean up heavy metal contaminated soil.

Conclusions and Recommendations: Increased in the lead concentration applied resulted in the decreased in the stem girth, plant height and fibre yields of kenaf and the more was the Pb absorption by kenaf in the two soils. Epe soil with sand texture and pH 5.3 had higher absorption than UNAAB soil with sandy loam texture and pH 6.3. The residual Pb levels in the soils after harvesting were lowered than the applied concentrations. This shows that kenaf is very effective to clean up Pb contaminated soil. Further research could also be carried out on other varieties of kenaf at much higher concentrations of Pb and at varying soil pH.

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