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Full Length Research Paper

Phytoextraction of heavy metals by fluted pumpkin *(Telfaria occidentalis* Hooker *F.)* planted on oil contaminated soil amended with sawdust and siam weed (*Chromolaena odorata*) (L.) R.M. King and Robinson) leaves

Iyagba* A.G. and Offor U.S.

Department of Agricultural Science, Ignatius Ajuru University of Education Port-Harcourt, Nigeria

*Corresponding authors e-mail: apegragba@yahoo.com

ABSTRACT

Growth and heavy metals uptake of fluted pumpkin (*Telfaria occidentalis* Hooker F.) on oil contaminated soil amended with siam weed (*Choromolaena odorata* (L.) R. M. King and Robinson) leaves and sawdust were investigated. Application of amendments significantly influenced growth parameters (plant height, number of leaves and dry matter accumulation) of fluted pumpkin. From the results, treatment contaminated soil added with siam weed leaves and the control revealed highest overall growth performance and survival rate of the plant compared to plants grown in contaminated soil and treatment with sawdust. Uptake of heavy metals by fluted pumpkin and its sequestration varies among the treatments used. Treatments with sawdust enhanced higher and rapid uptake of heavy metals (1.5 ± 0.12^{ab}, 0.29 ± 0.13^{bc}, 0.36 ± 0.3^{ab}) as compared to amendments with siam weed leaves and contaminated soil alone. In addition, treatments with siam weed leaves gave higher tolerance index (87.6%) of the fluted pumpkin used while treatments with sawdust and untreated soil have 72.1% and 60.5% respectively. The leaves of fluted pumpkin were found to be suitable for uptake of heavy metals in an oil contaminated soil (Phytoextraction) and the plant can tolerate the effect of oil contamination in soil with the help of the amendments through successive biomass accumulation. The plant is therefore recommended as a potential Phytoremediator in an oil contaminated soil.

Keywords: Heavy metals, oil contamination, amendments, *Telfaria occidentalis*, Phytoextraction and bio-remediator.

INTRODUCTION

Population growth coupled with accelerated development in technology has increased the quest for man's welfare of life which also posed serious environmental problems accruing from mining, oil exploration, mineral and agro-chemicals to mention a few. Environmental problems are critically important due to the direct harm they impose in human health and life cycles. Hazardous waste contamination is an environmental problem which usually comes from industrial activities such as mining, drilling/oil spillage, smelting of ferrous and non-ferrous ore, fertilizer-pesticide application or improper disposal of municipal waste (Sampanpanish *et al*., 2008). These activities result in hazardous waste that is released into the soil, water and ground water (Kabata-Pendias and Pendias, 2001). The effects of oil degradation and contamination on soil in plants has resulted in growth inhibition, morphological damage as well as biochemical pathways deviation from norm and other plant functions

(Offor and Akonye 2004, Ouncea *et al,* 2005).

The ability of plants to respond to oil contamination and heavy metals sequestration depends on an inter-related network of physiological and molecular mechanism such as:

(i) the absorption and accumulation of metals through binding to extra cellular exudates and cell wall constituents,

(ii) movement (efflux) of heavy metal from cytoplasm to extra nuclear compartments including vacuoles,

(iii) complexation of heavy metal iron inside the cell by osmoprotectants and

(iv) activationor modification of plant metabolism to allow adequate function of metabolic pathway, and rapid repair of damaged cell structures (Cho *et al.,* 2003).

Fluted pumpkin *(Telfaria occidentalis* Hooker F.) which belongs to the gourd or calabash family, curbitaceae is a strong growing vine and native to West-Africa. It is a large delicious perennial crop which climbs by means of coiled tendrils. It is cultivated mainly for its succulent tender shoot. It is a vegetable as the tender green leaves make a useful addition to diets. The highly nutritious seeds can be left in the fluted gourd unbroken until required. The seeds are also nutritious and rich in oil which may be used for cooking and soap making.

Siam weed (*Chromolaena odorata* (L.) R.M. King and Robinson) is a troublesome weed of cultivated fields, road sides and plantations (Akobundu, 1987). Iyagba (1994) noted that the weed has a growth habit adaptable to dry as well as water-logged and saline conditions which is unsuitable for the growth of most plants. Aro *et al*. (2009) recorded that its ability to survive long spells of drought as occasioned in many tropical areas and its propensity to resume active growth at the commencement of the rains is unparalleled. They also stated that its soil-enriching prowess and its tendency to infiltrate new areas have recommended it as a plant of choice in fighting desert encroachment especially in the Sudano-Sahelian ecological zones of Africa. The weed has many economic uses in different parts of the world. It serves an excellent fallow crop in arable farming due to its fast growth and ability to suppress other weeds (Moham-Lal, 1960) while Sheldrick (1968) and Aya (1977) noted its use as fodder and green manure plant. Ibe *et al* (2008) recorded the effectiveness of siam weed as mulching material in the cultivation of okra. The work of Gill *et al*. (2013) revealed that aqueous extract taken from the stem, leaf and root of siam weed had significant inhibitory effect on the growth of the root, stem and leaf of cowpea while Tijani and Fawusi (1989) have reported on the allelopathic activities of crude method extract of the weed on seed germination and seedling growth of tomato. Aro et al. (2009) indicated that 2.5% of siam weed is possible egg yolk colourant for laying hens. Inya-Agha *et al*. (1987) indicated that the oil from the leaves have antibacterial activity against *Stapplococus aurens and Escherima coli.*

Phytoremediation (green technology) is the use of vegetation for the insitu or exsitu treatments of contaminated soils, sediments and polluted water to detoxify organic and inorganic metals (Damian and Damian, 2007, Atkar *et al,* 2010). Sampanpanish *et al*. (2008) viewed phytoremediation as a biological methodology which uses selective plants for removing heavy metals from soil. Various workers have used C. *odorata* , Vetiver grass (*Vetiveria zizarioides*), Node weed (*Synedrella nodiflora*) water leaf (*Talinum triangulare*) sword grass (*Imperata cylindrica*), as phytoremediators (Sampanpanish *et al*., 2006, 2008; Aiyesanwi *et al*, 2012 and Oti, 2013). Tanhan *et al*. (2007) stated that *C. odorata* is a new phyto Pb hyper-accumulator while Sampanpanish *et al.* (2008) showed that root uptake of Cd, Zn, Pb and Cu was greater than that of stem and leaves using C. *odorata* and V. *zizanoides*. These two plants they indicated have ability to accumulate total heavy metals along with their wide distributions, fast growth, hardiness and easy maintenance. They also have short life span, high rate of propagation, and large biomass and tolerate multiple heavy metal contaminates from soil (Sampanpanish *et al*. (2006). Sawdust is used as an effective lignin based soil conditioner (LSC) because it has an adhesive affinity both for mineral soil particles and the organic surface of the lignocellulose. (Shulga *et al*, 2007). Due to its mulch biodegration it enriches the soil with the main nutrient elements and creates favourable conditions for plant growth. For effective and long term remediation of degraded soils, non-edible and metal tolerant species of plants are recommended. This work was therefore carried out to determine the suitability of using sawdust and siam weed leaves as phytoremediators in a contaminated soil grown with fluted pumpkin.

MATERIALS AND METHODS

The study was conducted in the Biological garden of the University of Port Harcourt, Nigeria. Seeds of fluted pumpkin used were purchased from the Omoku market in Ogba/Egbema Ndoni Local Government Area of Rivers State, Nigeria. The crude oil was supplied by Agip oil company Ebocha Base (Bonny type) Port Harcourt, Nigeria. Siam weed leaves and sawdust were obtained from a local farm and a saw mill respectively along the University of Port Harcourt axis.

A good garden soil weighing approximately 6600g was obtained and used to fill black cellophane bags of diameter measuring 50cm and height 45cm leaving a space of 7.00cm from the top end of the polythene bags to make allowance for crude or addition of amendments and water. Healthy looking seeds which have previously been tested for viability (96%) were first soaked in alcohol for 30 seconds to kill seed pathogens and then soaked in water for 24 hours before being sown deeply in the

Table 1. Heavy metal content of contaminated Soil before amendments and planting with fluted pumpkin

Heavy metal	Concentration (ppm)
Zinc (Zn)	1.20
Copper (Cu)	1.20
Chromium (Cr)	5.00

cellophane bag at the rate of 4-5 seeds per bag. Four hundred ml of crude oil was added and thoroughly mixed with the soil using a hand trowel. Sawdust and siam weed leaves were used as amendments at the rate of 50g per bag. The siam weed leaves were previously chopped with knife to ease mixing.

Experimental Design

A randomized complete block design was used. The seeds of fluted pumpkin were grouped into four treatments viz:

1. Treatment G - control which consist of the garden soil alone.
2. Treatment TGC- contaminated soil.
3. Treatment XTGC - contaminated soil plus siam weed leaves
4. Treatment STGC-contaminated soil plus sawdust

Each treatment was replicated three times and each replicate consist of four (4) seeds.

Morphological Characterization

After a growth period of six weeks fluted pumpkin leaves were harvested. Growth performance (number of leaves, plant height and dry weight) were determined per plant. For dry weight, samples were left in a desiccator for 48 hours until constant weight was obtained.

Tolerance Index

Tolerance index of the plant was computed using Wilkins (1978) viz.

$$\text{Tolerance index} = \frac{mean\ height\ of\ plant\ in\ conta\min ated\ \text{soil}}{mean\ height\ of\ plant\ in\ garden\ soil} x \frac{100}{1}$$

Statistical Analysis

The results obtained were subjected to analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) was used to separate means according to the procedure on statistical analysis system (SAS).

RESULTS AND DISCUSSION

The oil contaminated soil has higher concentration of copper and zinc as shown in Table 1. Oil contamination affected the growth and performance of fluted pumpkin in different treatments. The control has the highest vine length while treatment with siam weed leaves yielded the highest number of leaves per plant. Oil contaminated soil planted with fluted pumpkin with no amendment showed highest dry matter accumulation (Figure 1).

These findings showed that among all the treatments used, amendments with siam weed leaves significantly resulted to better performance of fluted pumpkin than application of sawdust and contaminated soil with no amendment. The fact remains that siam weed leaves contained better nutrients composition and enhanced microbial activity than sawdust. This result agrees with pervious works that attest to growth inhibition of plants due to nutrient deficiency, oil toxicity and water tolerance imbalanced by oil contaminants and metal stress (Sanjeet *et al.,* 2001; Zueng-Sang, 2000; Akonye and Onwudiwe, 2004;Yadaw *et al;* 2009 and Gupsa *et al*; 2011).

In relation to tolerance index, fluted pumpkin revealed higher tolerance index of 87.6% at treatment with siam weed leaves while treatments in garden soil and soil with sawdust which had 60.5 and 72.1% respectively. These findings inferred that treatments with siam weed enhanced growth and establishment of fluted pumpkin more than other treatments. From previous works, Tordoff *et al* (2000) and Walter *et al* (2004) have shown that amendments are known to reduce bio availability of heavy metals in growth medium, thus preventing the re-establishment of vegetation on contaminated soil.

Results on sequestration of heavy metals by fluted pumpkin also varies with treatments. *Chromolaena odorata* in general showed effective and potential properties of phytoremediation through hyper accumulation of degraded soils (Table 2). Higher uptake and sequestration of heavy metals was higher in treatment with sawdust averaging 1.15, 0.29 and 0.36 (ppm) for Cu, Zn and Cr respectively. Soil treated with siam weed leaves showed lower uptake and sequestration of heavy metals in fluted pumpkin. This trend gave an explanation why treatment with siam weed leaves has the highest growth performance because of

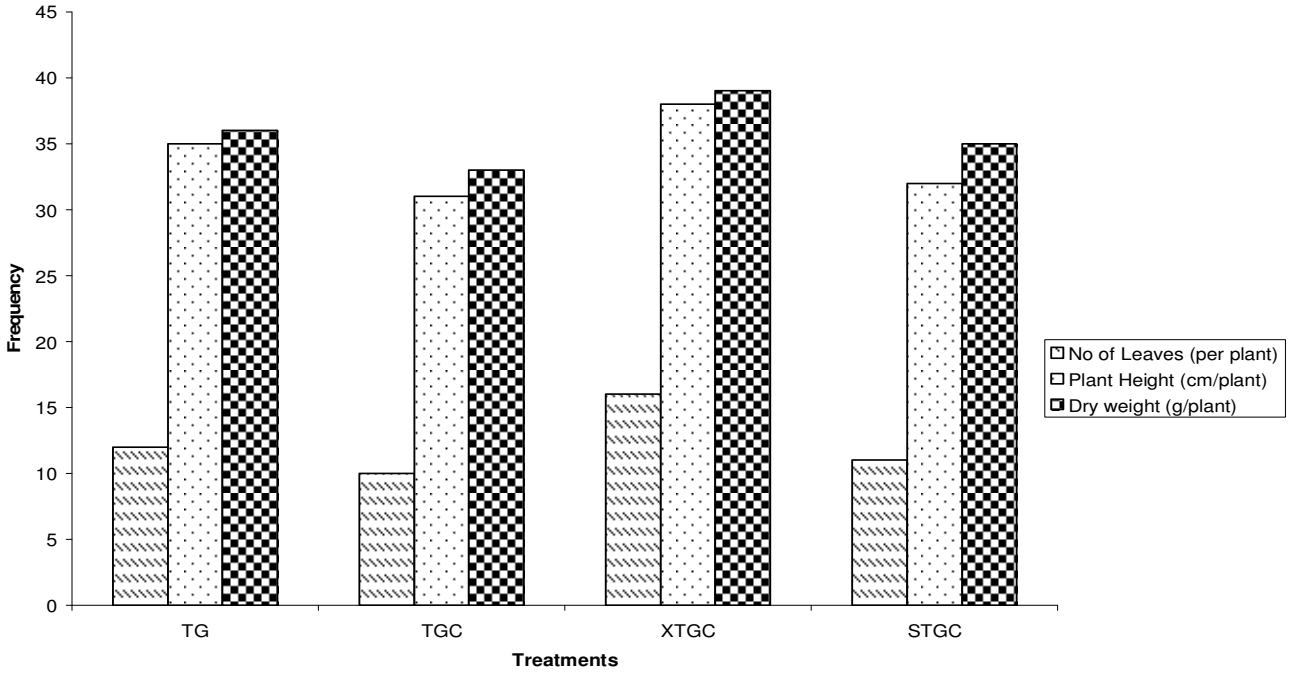

Figure 1: Growth Performance of *Telfaria Occidentalis* planted on Garden soil and contaminated soil with and without amendment

Table 2. Heavy metal content of fluted pumpkin planted in garden soil, oil contaminated soil with and without amendments

Treatments	Cu, (ppm)	Zn (ppm)	Cr (ppm)
TG	1.00 ± 0.12^{ba}	0.24 ± 0.02^{bc}	0.25 ± 0.03^{d}
TGC	0.96 ± 0.12^{h}	0.15 ± 0.02^{dc}	0.16 ± 0.02^{dc}
XTGC	1.03 ± 0.12^{bd}	0.19 ± 0.02^{d}	0.25 ± 0.03^{d}
STGC	1.15 ± 0.12^{ab}	0.29 ± 0.03^{bc}	0.36 ± 0.03^{ba}

its selective regulation and uptake of heavy metals to ensure long term survival and sustainability of fluted pumpkin while treatments in garden soil and application of sawdust effectively removed the heavy metals but growth and survival of the crop was inhibited. The works of Sampapanish *et al*.

(2008) and Oti (2013) showed higher accumulation of heavy metals (Cd, Zn, Pb, Cu) which were greater in the roots than that of the stem and leaves of siam weed. Using the weed leaves as mulching material in the cultivation of fluted pumpkin will assist in remediating oil contaminated soil. Though the findings of Tijani and Fawusi (1989) and Gills *et al*. (2013) revealed that extracts from siam weed have allelopathic effects on plant growth, this study and that of Samponpanish *et al*. (2006, 2008), Aiyesanmi *et al*. (2012) and Oti (2013) showed the plant as a good phytoremediator in contaminated soils.

TG = Garden Soil
TGC = Garden Soil Polluted
XTGC = Garden Soil Polluted and Treated with siam weed leaves
STGC = Garden Soil Polluted and Treated with Sawdust

CONCLUSION

Chromolaena odorata has shown to be an effective and suitable phytoremediator because of its ability to reclaim contaminated soil and accumulate higher amount of heavy metals. The application of amendment agents has also enhanced its remediating potentials and siam weed leaves proved very effective.

Results are presented as means of three replicates and means followed by different letters are significantly different using DMRT at 5% level.

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