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Chlorophyll and Proteincontents of Fluted Pumpkin (Telfariaoccidentalis) Planted on Heavy Metal Contaminated Soil in Response to Different Organic Amendments

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Abstract

Contamination of agricultural lands by heavy metals poses serious threat on human health through food chain. The use of organic amendments to immobilize metal in contaminated medium and prevent crop contamination is preferred because of its cost-effectiveness and environment-friendliness. In this research, effects of different organic amendments (Mexican sunflower extract, Compost, Compost tea and poultry manure tea) were tested on the growth, chlorophyll contents lead uptake, protein and yield of Telfaria occidentalis (Fluted pumpkin) grown on lead polluted soil. These were applied at different rates and period (two week before and after planting of ugwu seeds). Results showed that T. occidentalis grown on organic amended soils performed better in all the parameters considered compared to control (contaminated soils only). Amendment with organic materials increased the vine length, number of leaves, fresh and dry weight. Application of the treatments two weeks before planting was better than after planting. In terms of chlorophyll contents those treated with organic materials had more chlorophyll than control. Organic treated soil also reduced Pb concentration in the crop compared to untreated contaminated control. Organic amendment therefore, enhanced crop growth on contaminated soil and reduced metal accumulation.

Introduction

The issue of land contamination by heavy metal which stemmed from increase in urbanization and industrialization is now posing a great challenge to agricultural production most especially in the developing countries. This has led to several hectares of land mostly in urban and peri-urban centres being contaminated by heavy metals thereby reducing the amount of cultivable land for crop production. Soil contamination apart from reducing the agricultural productivity also poses significant threat on human health through food chain (Eriyamremu *et al.* 2005). Toxic levels of lead (Pb) in cultivated crops have been widely reported (Sharma *et al.*, 2007). Heavy metals are said to enter into animals and human beings through ingestion of contaminated plants/crops (CDC, 1991).

Vegetables are important part of human diet all over the world. It constitutes a potential source of nutrients and food components which have significant health effects. *Telfaria occidentalis* (Fluted pumpkin)popularly known as Ugwu, is one of the popular vegetables widely consumed in the Eastern/Western parts of Nigeria for its medicinal and nutritive values. It has high concentration of iron

(Fe) which makes it a source of food supplements for people suffering from blood shortages. It is mostly cultivated by women in urban centres along with other vegetables. With the recent advocate on the promotion of urban and peri-urban agriculture coupled with the exhaustion and unavailability of cultivable arable lands in urban and peri-urban areas, contaminated lands are being converted to agricultural uses thereby posing a lot of risks to human health. Conventional methods to clean up metal contaminated soils are capital intensive, not applicable to large areas and some are not sustainable.

The available options are development of sustainable strategies to remediate these lands or immobilize the contaminants thereby preventing their uptake. In this study, different forms and types of organic amendments (dry compost, compost tea, green manure tea and poultry manure tea) applied at different rates on the growth, Pb uptake, chlorophyll content, Protein and yield of *Telfariaoccidentalis* were assessed. Assessment of the effects of organic amendments on the growth and biochemical properties of crops grown on contaminated soil will help in determining the efficiency of different forms of organic amendments on metal uptake by crop and provide understanding of their effects on crop yield. The major aim was to increase soil nutrient contents and pH with these materials so as to increase yield and decrease Pb uptake by Ugwu grown on contaminated soil.

Materials and Methods

Description of the experimental site and soil sampling procedure

The study was carried out using the soil collected from a lead-acid battery waste contaminated site at Kumapayi village in Egbeda Local Government Area, Oyo State, Nigeria. The site contains high amount of heavy metals(Pb: 138,000mg/kg, Cu: 482mg/kg, Zn: 1510mg/kg, Cr: 12.3mg/kg and Cd: 41.3mg/kg) (Adejumo*et al.*, 2011) and covers about 24,985 m^2. Soil sampling was carried out at 0-15cm depth and specific quantity of soil was taken at five different locations for physico-chemical analysis and pot experiment. The soil was homogenized, air-dried and sieved.

Preparation of different organic products used for the experiment

Organic amendments used include; Mexican sunflower extract, Dried compost, Compost and poultry manure tea. Leachate production from fresh *Tithoniadiversifolia* was carried out by cutting the middle aged plants, weighed to know the fresh weight and then packed inside a 250 litres capacity plastic pot using partially aerated composting technique. The pot was perforated at the bottom and placed on a 50litres capacity bucket to collect the leachates. Dried compost was made from Mexican sunflower and Poultry manure in ratio 3:1 using PACT techmique (Adedirane *t al.*2001) and Poultry manure tea was prepared using partially aerated extraction method as described by Pant *et al.*, (2012) with small modifications.

Experimental procedure

The five treatments (Mexican sunflower leachate; SL, Poultry manure tea; PM Compost tea; COT, Compost; COM and Control) were replicated 4 times using three application rates (0, 20t/ha, 30t/ha and 40t/ha). The treatments also included application period (one week before (BP) and after planting (AP) of Ugwu seeds). For the compost tea and sunflower leachates, the quantity applied was calculated based on the amount of leachates produced from the known quantity of dry compost and fresh *Tithoniadiversifolia* respectively. For compost application rate of 20t/ha, 30t/ha and 40t/ha, the quantity of tea or leachates applied was 15.15 (R1), 22.73 (R2), and 30.30mls (R3) per 5kgsoil for the soil receiving 20t/ha (R1), 30t/ha (R2) and 40t/ha (R3) respectively.

Data collection

Data were collected on yield parameters, Chlorophyll content using the method explained by Akparobi, (2009). Dry matter yield was determined at harvesting. The ash content was determined by ashing specific quantity of leaf sample in a muffle furnace at 500°C for 12hours. Nitrogen was determined using macrokjeldahl method and protein content was calculated by multiplying the values obtained for Nitrogen by 6.25 factor (Akanbi*et al.*, 2007). Lead (Pb) content of the edible part (Leaf) was determined by Adejumo *et al.* (2011) and analysed for Pb content using Atomic Absorption Spectrophotometer (AAS).

Data analysis: Data collected were analysed using analysis of variance and the means were separated using DMRT at 5% probability level.

Results

Dry matter yield of Ugwuon contaminated soil amended with organic materials

Both fresh and dry weight of ugwu planted on contaminated soil responded positively to organic amendments. The fresh weight was enhanced mostly by the application of compost before planting at every rate. It was increased by 143% in plant treated with the highest rate of compost compared to control. This was followed by those of COLR1BP and SLR1AP. he lowest value was however recorded in those treated with poultry manure tea after planting (PMR2AP). Similarly, the shoot dry matter yield also followed the same trend. The root fresh weight was enhanced with compost tea treatment which gave the highest value followed by sunflower leachate, both applied after planting (Fig 1).

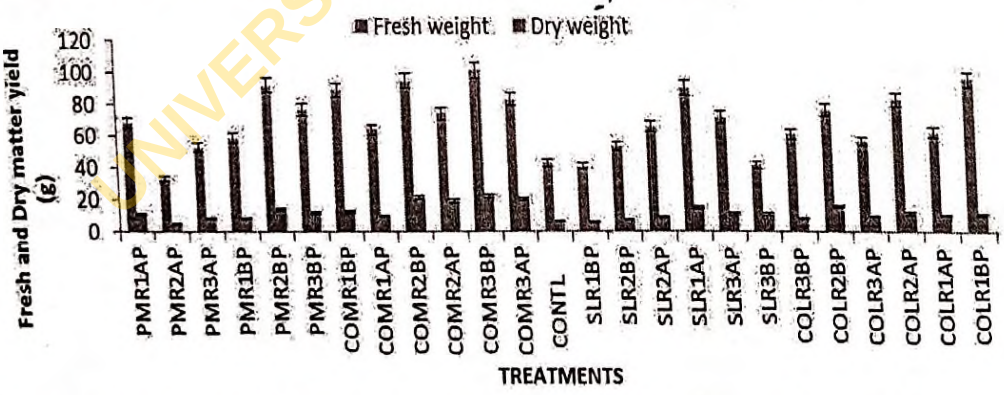

Figure 1: **Dry matter yield of Ugwuon contaminated soil amended with organic materials**

NB: Mexican sunflower leachate; SL, Poultry manure tea = PM, Compost tea = COL, Compost; COM and CONTL = Control on Pb soil, CONTN = Control on Normal soil) R1= 20t/ha, R2 = 30t/ha and R3 = 40t/ha; BP = Before Planting, AP= After Planting.

Heavy metal (Pb) uptake, Ash content, nitrogen and protein content of Ugwu* (Fluted pumpkin) *leaf from contaminated soil amended with organic amendments

The Pb concentration in the harvested ugwu leaf from Pb contaminated soil (825mg/g) was more than that of uncontaminated soil (5.34mg/g). Though, higher than the EU permissible level in edible plant part, application of organic amendments generally reduced the level of contamination by reducing the

concentrations of Pb in the harvested leaf compared to control. Lower rate of compost tea applied at two weeks after planting reduced Pb concentration in the leaf more than other treatments (16.01mg/g). Except in COLRIBP treatment, the ash contents of the Ugwu leaves from all the organic amendment treatments increased more than that of control from contaminated and uncontaminated soils. Addition of organic amendments in any form at any rate and different timing enhanced nutrient accumulation by ugwu leaf. The lowest was however recorded in the control from contaminated soil. The same trend was observed in terms of nitrogen and protein contents of ugwu leaf in response to different organic amendments since protein content is a factor of nitrogen content. However, those leaves from lead contaminated soil had more of nitrogen and protein than those from normal soil irrespective of the treatments except in COLR1BP and COLR3AP(Table 1).

Table 1. **Pb uptake, Ash content, Nitrogen and Protein content of Ugwu on contaminated soil**

Treatments	Pb (mg/kg)	Ash content (g/g/DW)	Nitrogen (%)	Protein content (mg/g FW)
CONTL	825.00a	0.03i	4.67e	31.38e
CONTN	5.34v	0.18g	4.01m	26.95k
COM R1BP	417.00e	0.49ab	5.13b	34.47b
COM R1AP	373.00g	0.47b	5.30a	35.62a
COMR2BP	362.50i	0.37cd	4.86c	32.66c
COMR2 AP	61.30s	0.46b	4.65e	31.25e
COMR3BP	362.50i	0.37cd	4.86c	32.66c
COMR3 AP	61.30s	0.46b	4.65e	31.25e
PMR2BP	362.50i	0.37cd	4.86c	32.66c
PM R2 AP	61.30s	0.46b	4.65e	31.25e
PM R1 BP	641.00c	0.33e	4.85c	32.60c
PM R1 AP	205.50p	0.34cd	4.75d	31.92d
PM R3 BP	217.00o	0.23f	4.31j	28.96h
PM R3 AP	227.00m	0.33e	4.25k	28.56i
COLR1BP	32.20t	0.11h	3.41p	22.92m
COLRIAP	16.01u	0.30e	4.88c	32.80c
COL R2 BP	123.00r	0.20f	4.50g	30.24f
COL R2 AP	177.00q	0.30e	4.53fg	30.44f
COL R3 BP	318.50k	0.52a	4.21l	28.29i
COL R3 AP	330.50j	0.53a	3.48o	23.39l
SLR2 BP	233.50l	0.24f	4.55f	30.58f
SLR2 AP	432.50d	0.36cd	4.88c	32.79c
SL R1 BP	364.50h	0.21fg	4.39i	29.50g
SL R1 AP	223.00n	0.49ab	4.39i	29.50g
SL R3 BP	767.00b	0.38c	4.10m	27.56j
SLR3 AP	379.00.f	0.50a	4.40h	29.57g

Means followed by the same alphabet are not significantly different from each other at P<0.05 using DMRT.
NB: Mexican sunflower leachate; SL, Poultry manure tea = PM, Compost tea = COL, Compost; COM and CONTL = Control on Pb soil, CONTN = Control on Normal soil) R1= 20t/ha, R2 = 30t/ha and R3 = 40t/ha; BP= Before planting, AP=After planting.

Chlorophyll contents

Lead contamination reduced the chlorophyll content by 50% in the ugwu plant grown on un-amended contaminated soil compared to those grown on normal soil. The result of the effect of organic amendments on the chlorophyll content of Ugwu planted on lead polluted soil showed that organic amendment enhanced chlorophyll formation in Ugwu planted on contaminated soil compared with control. The responses however varied based on the form and rate of organic materials. Addition of higher rate of dry compost both before and after planting (i.e COMR3BP and COMR3AP), poultry manure tea after planting, sunflower leachate before and after planting (SLR3BPand SLR3AP) increased the chlorophyll content by 50-55% compared to control plant on Pb contaminated soil (Fig 2).

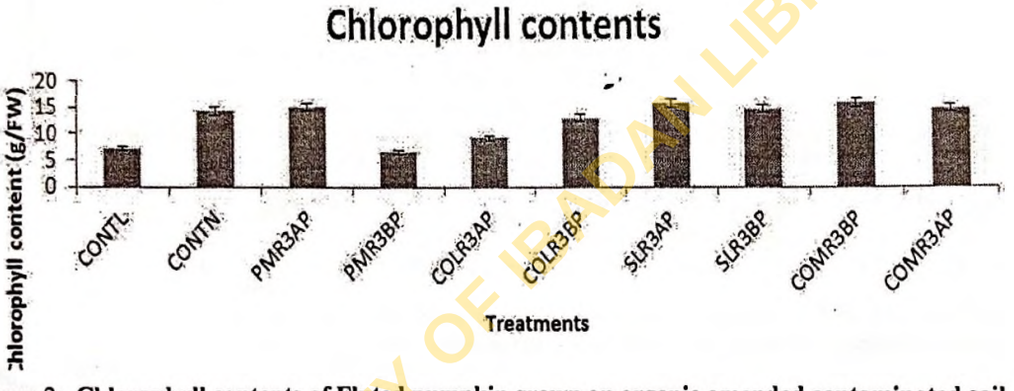

Figure 2: **Chlorophyll contents of Fluted pumpkin grown on organic amended contaminated soil**

Discussion

Organic amendments as previously reported (Chaney *et al.*, 2000; Adediran *et al.*, 2001; Adejumo 2010; Fleming *et al.*, 2011) was able to increase crop growth on this contaminated soil and reduced the metal uptake by the crop. The use of dry compost performed better than the tea or the leachate because it has the ability to be retained more in the soil than its liquid counterparts which are proned to leaching. Increase in the growth and yield of treated ugwu confirmed the previous reports on the ameliorative effect of organic amendments on heavy metal stressed plant (Fleming *et al.*, 2011). Availability of nutrient as well as the ability of organic amendment to increase pH and soil redox potential is said to help in reducing metal solubility and uptake by plant. As observed in this study, the Pb concentration in the organic treated plants (though higher than that of the uncontaminated soil), were lower than control(Salati*et al.*, 2010). The Chlorophyll concentrations of the leaves were significantly higher in Ugwu grown in organic amended contaminated soil. This confirmed the report that organic amendment increased the formation of organo-Fe complexes (Chen and Stevenson, 1986) which in turn enhances chlorophyll formation as Fe is very important in chlorophyll formation. Organic amendment has been reported to be a major source of iron-humate complex which has been reported to be more effective in increasing crop Fe-nutrition and has been used to correct Fe-deficiency in crop. With increase in chlorophyll content the photosynthetic ability of crop is also increased and this was revealed in the yield of Ugwu grown on amended soil as compared to control. Since ash content of the plant is a function of the nutrient composition of such plant, the control plant which probably had the lowest nutrient contents also contained the lowest quantity of ash. According to Hussain et al. (2012), stress factor such as heavy

metal contamination in plant enhances the production of stress protective proteins in plants as was observed in this study, where protein and nitrogen contents contrary to what was expected, were higher in all the plant from contaminated soil more than that of control plant from normal soil.

Conclusion

Organic amendments increased the yield of ugwu on contaminated soil. Encouraging and promoting the use of organic amendment will help in preventing contamination of this vegetable with heavy metals.

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