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Influence of cadmium on early growth of fluted pumpkin (*Telfairia occidentalis* Hook F.) and nutrient uptake in an ultisol

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Abstract: The greenhouse and field trials were conducted at the University of Benin, Benin City, Nigeria to determine the influence of Cd on the growth, dry matter yield and nutrient uptake by fluted pumpkin (*Telfairia occidentalis*). Four levels of $Cd(NO_3)_2$ treatments namely 0, 50, 100, 200 mg per 5 kg soil equivalent to 0, 20, 40, 80 $kgha^{-1}$ were used in the greenhouse and field trials respectively. The completely randomized and randomized complete block experimental designs were used in the greenhouse and field trials respectively. Results indicated that increased application of Cd decreased the height, number of leaves, leaf area, stem girth and dry matter yield of the plant. The nutrients content and uptake also decreased with the increase in the supply of the Cd. Higher Cd concentrations and uptake were recorded in the root of the treated plants when compared to the control treatments. The nutrients and oxides components of the soil decreased at various levels of the Cd application. These decrease in soil nutrient components were however not consistent. However, the Cd content of the soil increased with increased Cd treatments.

Keywords: Ultisol, Uptake, Yield, Metal excluder, Pumpkin

INTRODUCTION

Although cadmium is a naturally occurring element, it is rarely found a pure metal in nature. It is generally associated with oxygen, chloride, sulphates and sulphides and is often a by -product of extraction of Pb, Zn and Cu from their respective ores (ATSDR, 1999). The anthropogenic sources of Cd in the soil nowadays include the use of commercially available fertilizers and disposal of sewage sludge as soil amendments (Singh 2001, McBride, 2003). Others include pesticides, irrigation water, biomass burning, coal and oil combustion, mining activities, foundries and industrial refineries (Adriano, 1986). The cadmium (Cd) is one of those heavy metals that is toxic to plants and animals at low concentration. Cadmium can accumulate in high concentration in soils and it is recalcitrant in the soil profile particularly in the surface horizons (John, *et al.,* 1972, Khan and Frankland, 1983). The Cd is not very mobile and the immobilization can increase its concentration in the soil and ultimately lead to increase in toxicity of the contaminated soil.

The higher soil Cd concentration can result in higher levels of its uptake by plants (John *et al.,* 1972) and resultant bioaccumulation in the plant tissue. Investigation by Subramani *et al.* (1997) revealed that the germination and seedling growth of black grain (*Vigna mungo* (L) Hepper) showed a gradual decline with the increase in the concentration of Cd treatments. Kramer and Konig (1983) recorded high Cd content in the grain and vegetative parts of wheat and oat while Brown *et al.* (1983) reported high uptake of Cd by *Cynodon dactylon.* Nasu *et al.* (1984) also reported that Cd ion which is plant part specific in *Lemna pancicostato* suppressed its fronds multiplication and that the degree of the Cd effect depends on its concentration absorbed. *Beta vulgaris L, Rephenus sativus* and *Lycopersicum esulentus* did not extract appreciable Cd from soil at indigenous levels but following the initiation of elevated levels, Cd was detected in all the harvested crop tissues. The mineral nutrition acquisition by common bean plant as recorded by Azmat *et al.* (2005) also decreased with increase in Cd ion concentration. Pinero *et al.* (2002) reported that at higher concentration of Cd the biomass production, chlorophyll concentration of common bean (*Phaseolus vulgaris*), Alf-alfa (*Medicago sativa*), Avena (*Avena sativa*) and Rye grass (*Lotium multiflorum*) decreased to levels below the control.

However, Re *et al.* (1983) showed that Cd accumulation by 'different plant parts could reach a saturation level without the appearance of phytotoxic symptoms. Therefore, Cd pollution of the soil could remain undetected even when the plants were grown in the presence of consistently high level of Cd. Crops which exhibit this character tends to accumulate Cd where it is detoxified by binding to phytochelatins, a family of thiol-

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(SH) rich peptides (Stiffens, 1990 and Rauser, 1990).

The uptake of this cadmium by crops results in the bioaccumulation of the metal in the plant tissue. One of the ways by which this Cd is consumed is via the food chain and if the consumption through crops sources is not carefully regulated it may lead to accumulation in man with high attendant health hazards. The consumption of Cd has been reported to cause gastro intestinal, hematological, musculoskeletal, renal, neurological and reproductive adverse health effects (ATSDR, 1999).

The plant pumpkin (*Telfairia occidentalis*) is a herbaceous annual creeping or climbing crop that grows to about 6m in length. The soft round stems have large leaves that are trifoliate. The crop can produce up to 3-6 pods and the number of seeds per pod depends on the size of the pod. The seeds and leaves are widely consumed in tropical Africa and the plant is highly nutritive. This study was undertaken to determine the influence of Cd on some soil chemical properties, nutrient content and uptake and some growth parameters of *T. occidentalis.*

MATERIALS AND METHODS

The greenhouse and field trials were conducted at the experimental site of the Faculty of Agriculture, University of Benin, Benin City, Nigeria.

Greenhouse trial: In the greenhouse trial, soil samples were collected from surface 0-15cm depth, bulked, mixed thoroughly, air dried and then sieved to remove debris. Thereafter, 5 kg of the composite soil was weighed and put in each of the plastic pots. Thirty-six pots were used with twelve pots per replicate and three pots per treatment. Four levels namely 0, 50, 100 and 200 mg $Cd(NO_3)_2$ per 5 kg soil were used. The soils were polluted two weeks before transplanting one seedling per polythene pot to enable the Cd equilibrates with the soil. The experiment was organized in a completely randomized design with three replicates. Watering and weeding were carried out regularly. The trial was left for 40 days and thereafter the crops were harvested. The shoots were separated from the roots, dried in a ventilated oven at 70% for 48 hours to constant weight used in determining nutrient uptake. Prior to oven drying, data on height, number of leaves, stem girth and leaf area was taken. The plant height was determined by measuring from soil level to the tip of the topmost leaf. The heights of the entire plants in a treatment were used and mean computed. The number of leaves of all the fully opened leaves per pot was counted in a treatment and the mean taken. The stem girth was determined with a measuring tape. Also the entire plants in a treatment were used and the mean calculated. The leaf area of the entire opened leaves per plant were used. The leaf area was determined using the leaf area meter.

Field trial: The field experiment was sited where the soil for greenhouse trial was taken. The trial was carried out in a plot size of 10 m x 12 m (120 m^2). The same $Cd(NO_3)_2$ rates of 0, 50, 100, 200 mg per 5 kg soil equivalent to 0, 20, 40, 80 kg ha^{-1} were used. Each treatment was represented by a bed size of 1.6 m x 1.6 m separated by 50 cm space while each replicate was separated by 1 m alley. The various levels of $Cd(NO_3)_2$ were uniformly applied, thoroughly mixed and then left for two weeks before transplanting the seedlings. The seedlings were sown at a spacing of 1 m x 1 m with four seedlings per bed. Weeding and watering carried out regularly. The trial lasted for 40 days. The mode of data collection was similar to that of the greenhouse trial.

Soil analysis: Soils were analyzed at the beginning and at the end of the trials. Soil pH was determined by using pH meter while the soil particle size was done by hydrometer method of Bouyoucos (1951) as modified by Day (1965). The organic carbon was determined by chromic acid wet oxidation procedure of Walkey and Black (1934) as modified by Black (1965). The total N was determined by micro-kjeldal procedure as described by Jackson (1962) whereas the available P was extracted by using Bray No 1 P solution, and the P in the extract assayed calorimetrically by molybdenum blue colour method of Murphy and Riley (1962). The exchangeable bases were extracted using 1 N neutral ammonium acetate solution. The Ca and Mg content of the extract were determined volumetrically by EDTA titration procedure (Black, 1965). The K and Na were determined by flame photometry and Mg content obtained by difference. The heavy metals and oxides were determined by methods Soon and Abboud (1993). The data generated were analyzed by Genstat statistical version 6.1.0 234 (Payne, 2002).

Plant analysis: The plant materials were ground (< 1 mm) and then digested with a mixture of HNO_3, H_2SO_4 and $HClO_4$ acids (IITA, 1979). The mineral ions (Na, K, Ca, Mg, Fe, Mn, Zn and Cd) were determined by the use of atomic absorption spectrophotometer (AAS UNICAM 969). For P content (AOAC, 1970) perchloric acid digestion (wet oxidation) method was used while the micro-kjeldal method of Jackson (1962) was used for N determination.

RESULTS AND DISCUSSION

Properties of the soil used : The properties of the soil used are shown in Tables 1and 2.The soil used is acidic and texturally sandy loan. The soil is low in fertility and have low Cd component that is below the (WHO, 1984) acceptable level of 0.3mgkg^{-1}. In the greenhouse and field trials, the Organic carbon, N, P, K, Mg, Ca, Na, Fe, Mn, and Zn components of the soil declined after the trial. The decline of these nutrients was not consistent and this inconsistent decrease may be attributed to plant uptake at various levels of Cd treatment. The Cd content of the soil also increased with increase in Cd application.

Table 1. Some physico-chemical properties of the soil used in the trial.

Properties	Greenhouse value	Field value
pH(1:1)	5.01	5.65
Organic carbon (%)	4.10	4.30
Total N (%)	0.60	0.67
Av P ($mgkg^{-1}$)	2.63	2.70
Ca $cmolkg^{-}$	1.60	1.63
Mg $cmolkg^{-}$	0.30	0.31
K $cmolkg^{-1}$	0.09	0.10
Na $cmolkg^{-}$	0.06	0.09
Free Fe Oxides %	4.93	4.92
Free Al Oxides %	0.74	0.76
Amorphous Fe oxide %	0.07	0.06
Amorphous Al oxide %	0.03	0.03
Cd $mgkg^{-1}$	0.001	0.001
Fe $mgkg^{-1}$	0.03	0.04
Mn $mgkg^{-1}$	0.05	0.05
Zn $mgkg^{-1}$	0.24	0.27
Sand gkg^{1}	865.31	864.32
Silt gkg^{1}	12.39	14.37
Clay gkg^{1}	122.30	121.31
Textural class	Sandy loam	Sandy loam

The increase in soil Cd component is attributed to increase in amount of Cd applied. The increase in concentration of Cd in the soil used correspond to the studies of Kachenko and Singh (2004) and Tam and Singh (2004) who reported similar high concentration of Cd in soil from within the smelter compound. The oxides also declined at the various levels of Cd treatments. The decrease in oxides also may be due to the oxide solubility at low soil pH. Schwertmann (1991) has earlier reported similar results of oxides solubility at low soil pH. The oxides according to Schwertmann (1991) are very low at the pH range of soils and depend on the particle size, crystalinity and percent of Al substitution.

Effect of cadmium on plant height, number of leaves, leaf area, stem girth and dry matter yield of *T. occidentalis*: Table 3 indicated the effect of the Cd on the growth and dry matter yield of the pumpkin. The height, number of leaves, leaf area and stem girth decreased with increase in the concentration of Cd applied. The Cd rates influenced the growth parameters so much that the treated plants consistently gave low values compared to the control. The various treatments were however not significantly different from one another in the growth parameters. This retarded growth recorded especially in those treated with Cd is a commonly observed growth response in a wide range of plants cultivated in metal laden soils as reported by Foy *et al.* (1978). The Cd treatment also had an appreciable effect on the shoot and root dry weight of the plant (Table 3) with significant differences recorded among various Cd

Table 2. Some chemical properties of the soil used after the greenhouse and field trials.

Heavy metal	Rate mg/5kg soil	pH (H_2O 1:1)	Org C (%)	Av P $mgkg^{-1}$	Total N (%)	Ca $cmolkg^{-1}$	Mg $cmolkg^{-1}$	K $cmolkg^{-1}$	Na $cmolkg^{-1}$	Fe $mgkg^{-1}$	Mn $mgkg^{-1}$	Zn $mgkg^{-1}$	Free oxide Fe %	Free oxide Al %	Amorph oxide Fe %	Amorph oxide Al%	Cd $mgkg^{-1}$
									Greenhouse trial								
Cd	0	5.67b	2.81b	1.08b	0.43a	0.92a	0.20a	0.04a	0.03a	0.02a	0.03a	0.16a	3.12a	0.03a	0.02a	0.02a	0.001d
	50	5.71b	3.04a	1.45a	0.37b	0.79b	0.18b	0.05a	0.03a	0.02a	0.04a	0.16a	3.05a	0.03a	0.01a	0.01a	47.04c
	100	5.78a	2.60c	1.17b	0.27c	0.81b	0.12c	0.05a	0.03a	0.02a	0.04a	0.14a	2.97a	0.03a	0.01a	0.02a	80.84b
	200	5.82a	3.00b	1.17b	0.41ab	0.82b	0.12c	0.04a	0.02a	0.02a	0.04a	0.13a	2.78a	0.03a	0.02a	0.02a	117.57a
	Kgha-1								Field trial								
Cd	0	5.89a	4.19a	2.21a	0.48a	0.59a	0.24a	0.06a	0.08a	0.02a	0.02a	0.12	3.92a	0.04a	0.05a	0.02a	0.001d
	20	5.25b	3.68a	1.12d	0.41b	0.69a	0.25a	0.07a	0.07a	0.03a	0.03a	0.16a	2.91b	0.03a	0.05a	0.01a	36.30c
	40	5.47b	3.80a	1.42c	0.45b	0.57a	0.25a	0.07a	0.07a	0.02a	0.03a	0.15a	3.42ab	0.02a	0.04a	0.01a	67.55b
	80	5.57b	3.61	1.54b	0.40b	0.63a	0.26a	0.07a	0.08a	0.02a	0.03a	0.16a	3.14b	0.02a	0.04a	0.01a	112.72a

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability

Table 3. Effect of cadmium on plant height, number of leaves, leaf area, stem girth and dry matter yield of *T. occidentalis* in greenhouse and field trials.

Heavy Metal	mg/5kg soil	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Stem girth (cm)	Shoot dry weight (g)	Root dry weight (g)
				Greenhouse trial			
Cd	0	63.17a	23.67a	26.63a	2.75a	4.83a	0.86a
	50	59.37a	23.33a	24.20a	2.20a	3.55ab	0.75b
	100	46.33a	21.37a	23.80a	2.00a	3.29ab	0.66c
	200	38.83a	19.67a	19.58a	2.00a	2.39b	0.58d
	$Kgha^{-1}$			Field trial			
Cd	0	101.24a	36.11a	38.78a	3.16a	8.27a	1.56a
	20	80.00a	33.78a	38.22a	2.76a	5.84b	1.34b
	40	76.22a	32.67a	35.33a	2.21a	4.97b	0.94c
	80	68.55a	31.33a	28.44a	1.90a	3.58c	0.92c

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability

levels in greenhouse and field trials The dry weight also decline with increase in the concentration of Cd treatment. Orhue (2008) while citing Azmat and Haider (2007) reported that the depression in root growth in the Cd treated soils could be attributed to lack of oxygen because of the heavy metal application. Godzik (1993) reported that nutrients are generally absorbed against concentration gradients; consequently, respiratory energy is required for mineral uptake. In order for respiration to continue in the roots, oxygen must be available in root zone (Azmat and Haider, 2007). Roots, which become totally submerged in soil contaminated by heavy metals, will suffer from lack of oxygen, and this will lead to slow growth and inhibitory effect of toxic metal on root of plants (Jones *et al.,* 1973).

Shoot mineral nutrients and uptake by *T. occidentalis*: Tables 4 and 5 depicted the shoot mineral concentration and uptake respectively. Again, the nutrients concentration and uptake consistently decrease with increase in Cd application in the greenhouse and field trials. The mineral nutrients concentration (Table 4) in the shoot recorded significant differences among the various Cd treatments. The uptake (Table 5) of the minerals by the shoot recorded the control to be consistently significantly higher than other treatments. This result is similar to the findings of Eun *et al* (2002) who reported that high concentration of heavy metal causes imbalance of mineral nutrients in growing plants. These imbalances may have caused reduction in growth of the pumpkin plant treated with Cd. The decrease in the uptake of nutrients by shoot may be attributed to a decrease in nutrient content because of increase in Cd application. Reduction in nutrient content and internal ratios of nutrients may have occurred in the pumpkin under Cd stress as earlier reported by Pinero *et al.* (2002).

Root mineral nutrients and uptake by *T. occidentalis*: The mineral ion concentration and uptake in the root are shown in Tables 6 and 7 respectively. These minerals and their uptake also declined with increased Cd concentration. In the greenhouse and field trials, significant differences were detected among the various levels of Cd in the mineral content of the root. The uptake of these minerals by the root in the greenhouse and field trials also recorded significant differences among the various treatments. The alteration of mineral elements in the root by the Cd treatment may be attributed to Cd physically blocking mineral ions from the absorption site of roots leading to reduction in root growth as shown by

Table 4. Shoot mineral content as influenced by various levels of cadmium in the greenhouse and field trials (%)**.**

Heavy metal	mg/5kg soil	N	P	K	Mg	Ca	Na	Fe	Mn	Zn
					Greenhouse trial					
Cd	0	3.04a	0.56a	3.79a	0.92a	2.69a	3.11a	0.32a	0.40a	0.48a
	50	2.90b	0.48b	2.81b	0.83b	1.07b	2.17b	0.25b	0.34b	0.32b
	100	2.36c	0.38c	1.77c	0.71c	0.89c	2.03c	0.15c	0.16c	0.16c
	200	1.78d	0.28d	1.07d	0.61d	0.78d	0.81d	0.11d	0.11d	0.10d
	Rate $kgha^{-1}$				Field trial					
Cd	0	2.36a	0.27s	3.57a	0.84a	2.84a	3.17a	0.24a	0.35a	0.43a
	20	2.13b	0.22b	2.69b	0.71b	0.96b	2.44b	0.18b	0.24b	0.24b
	40	2.02c	0.18c	2.09c	0.64c	0.61c	2.04c	0.13c	0.19c	0.13c
	80	1.77d	0.15d	1.03d	0.48d	0.46d	1.23d	0.07d	0.13d	0.05d

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability.

Table 5. Shoot mineral uptake as influenced by various levels of cadmium in the greenhouse and field trials (mgkg^{-1}).

Heavy metal	mg/5kg soil	N	P	K	Mg	Ca	Na	Fe	Mn	Zn
					Greenhouse trial					
Cd	0	136.51a	25.31a	170.22a	41.13a	135.62a	139.45a	14.21a	17.83a	21.70a
	50	103.37b	17.19b	99.89b	29.49b	38.17b	76.98b	8.80b	11.95b	11.43b
	100	77.81b	12.66b	58.21c	23.20b	29.19b	66.73b	5.01c	5.36c	5.11c
	200	43.05b	6.15c	25.37d	14.33c	18.88c	19.04c	2.79c	2.66c	2.48c
	Rate kgha^{-1}				Field trial					
Cd	0	195.00a	22.30a	296.10a	69.62a	235.71a	256.50a	19.74a	28.59a	35.46a
	20	123.90b	12.88b	164.00b	42.22b	56.06b	142.70b	11.61b	14.17b	14.78b
	40	100.10c	9.62c	109.00c	32.36c	31.56b	101.50c	6.72c	10.18c	6.82c
	80	63.80d	6.24d	77.60d	17.89d	18.20b	44.20d	2.75d	5.04d	2.07d

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability.

the root weight. The decrease on the root weight may also be related to the decrease in Ca root tips of the pumpkin leading to decrease in cell division or cell elongation (Rout and Das, 2003). Moreover, the Cd concentration may have damaged the tissue cells of vascular bundles, which resulted in the inhibition of conduction of water molecules and other nutrients from root to aerial parts of the plant hence there was a reduction in the plant nutrients. This reduction in plant nutrients is similar to finding of Eun *et al.* (2002) and Azmat *et al.* (2006).

Cadmium content (%) and uptake (mgkg^{-1}) by *T. occidentalis*: The Cd component of the crop is shown in Table 8. The Cd content of the shoot and root increased with increase in Cd application. In the greenhouse trial, the 200mg Cd treatment was significantly higher in the accumulation of Cd by shoot and the root. The 200 mg Cd treatment in the field also recorded high Cd concentration in the root while there were no significant differences among the treatment in Cd content of the shoot. In the greenhouse trial, the 200 mg Cd significantly had a higher value in Cd uptake by the shoot whereas the 100 mg Cd and 200 mg Cd were significantly higher than other treatments in root uptake of Cd. The 40 kgha^{-1} and 80 kgha^{-1} treatments were significantly higher than other application in Cd uptake by shoot and the root in the field trial. The uptake of Cd also increased with increase in the Cd application. In this study, the root accumulated more Cd than the shoot making the plant a metal excluder. The metal excluder (Raskin *et al.*, 1994) prevent metal from entering their aerial part or maintains low and constant metal concentration over a broad range of the concentration in soil and they mainly restrict metal in their root as shown by pumpkin in this study. A metal excluder restricts heavy metals to root by actively growing roots, which provide a barrier to the movement of heavy metal to above shoot. Jones *et al.* (1973), Malone *et al.* (1974), Begonia (2006) and Kumar *et al.* (1995) have earlier reported similar results with various broad leaf vegetables grown in various soils laden with heavy metals. Marcilene *et al.* (2003) also reported that Cd is generally present in higher rates in roots and moderate to great quantities in the aerial parts of plants.

The low concentration of Cd in the control plant at harvest is below the specified maximum acceptance level of 0.3 mgkg^{-1} for leafy vegetables by WHO (1984) and the Codex Alimentarius Commission (2004). The low level of this Cd in the control treatment makes the plant to be less

Table 6. Root mineral content as influenced by various levels of cadmium in the greenhouse and field trials (%).

Heavy metal	mg/5kg soil	N	P	K	Mg	Ca	Na	Fe	Mn	Zn
					Greenhouse trial					
Cd	0	1.24a	0.26a	0.99a	0.19a	0.73a	1.88a	0.03a	0.01a	0.02a
	50	1.17b	0.20b	0.94b	0.16b	0.62b	1.03b	0.02ab	0.01a	0.02a
	100	1.03c	0.15c	0.80c	0.12c	0.54c	0.92b	0.02ab	0.01a	0.01a
	200	0.99d	0.12d	0.58d	0.10d	0.41d	0.78c	0.01b	0.01a	0.01a
	Rate kgha^{-1}				Field trial					
Cd	0	1.15a	0.22a	0.93a	0.17a	0.72.a	1.72a	0.06a	0.04a	0.02a
	20	1.12a	0.16b	0.85b	0.14b	0.57b	1.49a	0.05ab	0.03ab	0.02a
	40	1.04b	0.11c	0.75c	0.11c	0.46bc	1.13b	0.03c	0.02bc	0.01a
	80	0.99b	0.10c	0.48d	0.09d	0.43c	0.99	0.02c	0.01c	0.01a

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability

Table 7. Root mineral uptake as influenced by various levels of cadmium in the greenhouse and field trials (mgkg^{-1}).

Heavy metal	mg/5kg soil	N	P	K	Mg	Ca	Na	Fe	Mn	Zn
						Greenhouse trial				
Cd	0	10.69a	2.23a	8.54a	1.63a	6.33a	16.17a	0.26a	0.11a	0.17a
	50	8.80b	1.53b	7.06b	1.22b	4.67b	7.77b	0.13b	0.08b	0.15a
	100	6.76c	1.02c	5.27c	0.74c	3.59c	6.08c	0.11b	0.03c	0.07b
	200	5.75d	0.68d	3.39d	0.56c	2.42d	4.59d	0.06b	0.03c	0.06b
	Rate kgha^{-1}					Field trial				
Cd	0	17.99a	3.39a	14.47a	2.65a	11.22a	26.94a	0.93a	0.67a	0.37a
	20	15.05b	2.14b	11.46b	1.92b	7.70b	21.83b	0.62b	0.40b	0.28ab
	40	9.47c	1.07c	7.11c	1.04c	4.35c	10.63c	0.30c	0.16c	0.10b
	80	9.05c	0.83c	4.43d	0.79c	3.30d	9.13c	0.18c	0.06c	0.09b

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability.

Table 8. Cadmium content (%) and uptake (mgkg^{-1}) by *T. occidentalis* in the greenhouse and field trials.

Heavy metal	mg/5kg Soil	Shoot Cd content	Root Cd content	Shoot Cd uptake	Root Cd uptake
			Greenhouse trial		
Cd	0	0.0001c	0.02d	0.004d	0.14c
	50	0.04bc	0.58c	1.39c	4.31b
	100	0.06b	1.14b	1.97b	7.50a
	200	0.13a	1.34a	2.61a	7.71a
	Rate kgha^{-1}		Field trial		
Cd	0	0.0001a	0.02d	0.008c	0.31c
	20	0.03a	0.45c	1.05b	6.02b
	40	0.04a	0.73b	1.28ab	6.74ab
	80	0.05a	0.81a	2.23a	7.43a

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability.

hazardous to man when consumed. Those treated with the Cd deviated from this acceptable level making it hazardous to health when regularly consumed.

Conclusion

In conclusion, the application of Cd had a negative influence on the growth parameters and dry matter yield of the plant. The nutrient content and uptake by the plant at various levels of treatment decreased with increased concentration of the Cd whereas the root of the treated pumpkin accumulated higher Cd ions than the shoot. However, the shoot of the control plants had low Cd component when compared to the treated plants. The soil nutrients content and the oxides also decreased at various levels of Cd treatment whereas the Cd component of the soil increased with increased Cd application. From the aforementioned results, it is advisable not to plant pumpkin in soils suspected to be laden or high in cadmium materials.

REFERENCES

Adriano, D.C (1986). Trace elements in the terrestrial environment, New York: Spinger Verlag.

ATSDR (1999). Toxicological profile for cadmium. U.S Department of Health Services. Agency for Toxic Substances and Disease Registry (ATSDA), 205-93-0606

AOAC (1970). Official methods of analysis, Association of Official Analytical Chemists (AOAC) Ed 11 Washington D. C.

Azmat, R and Haider, S (2007). Pb Stress on phytochemistry of seedlings *Phaseolus mungo* and *Lens culinaris*. *Asian Journal of Plant Science,* 6(2): 332-337

Azmat, R. Haider, S and Askari, S. (2006). Phytoxicity of Pb I: Effects of Pb on germination, growth, morphology and histomorphology of *Phaseolus mungo* and *Lens Culinaris*. *Pakistan Journal of Biological Science,* 9:979-984

Azmat, R., Iftikar, B., Khanum, T; Hayyat, A., Talat, R. and Uddin, F. (2005). The inhibition of bean plant metabolism by cadmium metal 11: The inhibition of mineral acquisition in heavy metal contaminated environments. *Pakistan Journal of Biological Sciences,* 8:748- 750

Begonia, G.B. (2006). Comparative lead uptake and responses of plants grown in lead contaminated soils. www.ejoun3.htm.

Black, C.A,(1965). Methods of soil analysis. Agronomy No 9 Part 2. America Society of Agronomy. Madison, Wisconsin.

Brown, K.W; Thomas, J.C. and Slowey, J.F. (1983). Metal accumulation by bermidagrass grown on four diverse soils amended with secondarily treated sewage effluent. *Water, Air and Soil pollution,* 20(4): 431-446.

Codex Alimentarius Commission (2004). Report of the 36th Session of Codex Alimentarius Committee on Food Additives and Contaminants Rotterdam, The Netherlands 22-26 March.

Day, P. R. (1965). Particle fractionation and particle size analysis: In methods of soil analysis, (C.A. Black Ed).Agronomy No 9 Part 1. American Society of Agronomy Madison, Wisconsin

Eun, S.O., Youn, H.S. and Lee, Y. (2002). Lead disturbs microtubile organization in root meristem of *Zea mays Physiology of Plants*, 110:357-365.

Foy, C.D., Chaney, R.L and White, M.C. (1978). The physiology of metal toxicity in plants. *Annual Review of Plant Physiology*, 29:511-566.

Godzik, B. (1993). Heavy metal contents in plants from zinc dumps and reference area. *Poland Botanical Studies*, 5:113-132.

International Institute of Tropical Agriculture (IITA) (1979). Selected methods for soil and plant analysis. Manual Series No 1. pp 70

Jackson, M.L.(1962). Soil chemical analysis. Prentice Hall, New York. 263-268

John, M. K., Vanlaerhoven, C. J. and Chukwuma, C. (1972). Plant uptake and phytotoxicity of cadmium added to soils. *Environmental Science and Technology,* 6 (2), 1005-1009.

Jones, L.H.P., Clement, C. R. and Hoope, M. J. (1973). Lead uptake from solution by perennial ryegrass and its transport from root and shoots. *Plant Soil,* 38:403-414.

Kachenko, A. and Singh, B. (2004). Heavy metals contamination of home grown vegetables near metal smelter in NSW. Super Soil: 2004 Australian/New Zealand Soil Conference, 5-9 December, 2004, Adelaide.

Khan, D. H. and Frankland, R. (1983). Effects of cadmium and lead on raddish with particular reference to movement of metals through soil profile and plant. *Plant and Soil,* 70: 335-345.

Kramer, F. and Konig, W. (1983). Cadmium contents in soil and plants: the growth and nutrient concentration of tomato and egg plant. *Plant and soil,* 74 (3):387-354.

Kumar, P.B.A.N., Dushenkov, V., Matto, H. and Raskin, I. (1995). Phytoextraction: The use of plants to remove heavy metals from soils. *Environmental Science and Technology,* 29:1232-1238.

McBride, M. B. (2003). Toxic metals in sewage sludge amended soil: Has promotion of beneficial use discounted the risk? *Advance Environmental Research,* 8: 5-17

Malone, C.D. Koeppe, D.E. and Miller, R.I. (1974). Localization of lead accumulated by corn plants. *Plant Physiology,* 53:385-394.

Marcilene, F. B., Marines, A. J., Margarate, S. S. and Ervin, L. (2003). Lead behaviors in soil treated with contaminated sewage sludge and cultivated with maize. *Brazillian Archives of Biology and Technology,* 46 (4): 1-11.

Murphy, J. and Riley, J. P. (1962). Analytical chemistry. *Acta,* 27:31-36.

Nasu, Y., Kugimoto, M., Tanaka, O., Yanase, D., and Takimoto A. (1984). Effect of cadmium, copper and cobalt existing in the medium on the growth and flowering of *Lemna pancicostata* in relation to their absorption. *Enviromental Pollution.* 33(3):262-274.

Orhue, E. R. (2008). Phytoavailability of lead and chromium to pumpkin in an ultisol Ph. D Thesis University of Benin, Benin City, Nigeria.

Payne, R.W. (2002). Gent stat 6.1: Reevence manual VSN International Ltd. Oxford.

Pinero, H.J.L., Miti, R.K., Julia-Verdestar, M.A., Diaz, G.G., Dnzalez, A.N., Cardenas-Avila, M.L. and Orough- Bakhih, R. (2002). Effect of Pb and Cd on seedlings, growth, chlorophyll and protein contest of common bean. *Phascolus vulgaris*, Alfalfa (*Medigago sativa*), Avena (*Avena santiva* and rye grass (*Lolum multiflorum*) selected as hyper accumulator of heavy metal. *Research on Crops*, 3:473-480.

Raskin, I., Kumar, P.B.A., Dushenkovs, N. and Salt, D. (1994). Bio-concentration of heavy metals by plants. *Current Opinion on Biotechnology,* 5: 285-290.

Rauser, W.E. (1990). Phytochelatins. *Annual Review of Biochemistry,* 59: 61-86..

Re, M., Gavagola, M.G., Crovato, E. and Cella, R. (1983). Cadmium distribution within corn plants as a function of Cadmium loading of the soil. *Environmental Research,* 30 (1) 44-49.

Rout, G. R. and Das, P. (2003). Effect of metal toxicity on plant growth and metabolism 1 Zinc. *Agronomie,* 23: 3-11

Schwertmann, U. (1991). Solubility and dissolution of iron oxides. *Plant and Soil,* 130:1-25.

Singh, B. (2001). Heavy metals in soils: sources, chemical reactions and forms In: Geo-environment proceeding of 2nd Australia and New Zealand conference of environmental geotechnic 2001 New South Wales.

Soon, Y. K. and Abboud, S. (1993). Cadmium, chromium, lead and nickel In: Soil sampling and methods of soil analysis (eds M.R. Carter). *Canadian Society of Soil Science,* 101-108.

Stiffens, J.C. (1990). The heavy metal binding peptides of plants. *Annual Review of Plant Physiology and Molecular Biology,* 41:553-575.

Subramani, A., Saravanan, S., Taraizhuiyay, P. and Lakshmanalharg, A.S. (1997). Influences of heavy metals non germination and early seedlings growth of *Vigna mungo* L. *Pollution Research,* 16(1): 29-31.

Tam, Y.L. and Singh, B. (2004). Heavy metals availability at industrially contaminated soils in NSW, Austral: In A.L. Juhaz, G. Magesan and R. Naidu (eds). Waste Management, Science. Publishers Plymouth 97 – 120.

WHO (World Health Organization) (1984). Guidelines for soil, water and plant quality. Vol. 1 Recommendation W.H.O. Geneva 130p.