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Impacts of Some Heavy Metals on the Growth and Development of Selected Vegetables Seedling

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Abstract: *An experiment carried out to study the impacts of some heavy metals on the growth level of selected vegetables seedling (cucumber, tomato, sweet pepper and carrot) grown on contaminated soil was examined. Metals were applied in four concentrations (20, 70, 120, and 200 mg/kg) and nutrient solution developed by Hoagland and Arnon was used to feed the seedlings. The amount of metals (Zn, Fe, Cu, Cr, Cd, Ni, and Mn) absorbed in the various part of the selected vegetables seedling were determined using Atomic Absorption Spectrophotometer after digestion. The uptake of iron (Fe) by plant parts were observed to be higher compared to other metals. It's clear that the addition of 20-70 mg/kg of selected metals (Zn, Fe, Cu, Cr, Cd, Ni, and Mn) induced a slight increase in plant root and shoot. However, at higher levels (120 and 200 mg/kg), root length and shoot length were all significantly reduced compared with control. The exposure to 200 mg/kg of the selected metals for 3 weeks reduced plants shoot of sweet pepper seedling by 53.84% followed by cucumber seedling (42.2%), tomato seedling (34.60%) and carrot seedling (27.5%) compared with control. Similarly, their root length was reduced by 45.71% in sweet pepper seedling, followed by carrot seedling (45.52%), tomato seedling (29.20%) and cucumber seedling (28.94%).*

Keywords: *vegetables seedling, growth, heavy metals.*

1.0 INTRODUCTION

Heavy metals lately have received the curiosity of scientific researchers throughout the world, due to their negative impact on plant. Heavy metals are metals having a specific weight greater than 5.0 g/cm^3(Tchounwou *et al*., 2012) and are toxic at high concentration in plants especially the essential metals (Monni *et al*., 2000).

Heavy metals are important as micro nutrients such as Fe, Zn, and Mn but can be harmful or toxic in higher amounts on plants and human body. Thus its importance to man's health is significant (Srinivas *et al*., 2009). Other heavy metals, such as Ag, Ni, Cu, Pb, Cd, andAs are toxic elements. Heavy metals can deteriorate air, water and soil quality, and afterward cause health challenge in plants, animals and mankind because they cannot be degraded to a small amount. They become relatively high as a result of industrial activities or anthropogenic activities. Possible areas or sources of heavy metals in the environment includes mining, industrial waste, construction works, effluent from insecticides and pesticides, fertilizers, run-off dumpster, burning of waste in rural areas and waste water from treated timber. Heavy metals like iron, tin, copper, manganese and vanadium are naturally occurring metals found in the environment and could serve as substance providing nutrients for plant growth depending on their concentration (Bassey *et al*., 2014). These heavy metals such as mercury, lead, cadmium, silver, chromium and so on are indirectly distributed as a result of mankind activities which could be very dangerous even at low concentrations. These metals are non-biological and can undergo global ecological circle (Opaluwa *et al*., 2012).

Due to agricultural activities and human activities mercury (Hg) quantity in water has increased. To substantiate this, water from domestic sewage, burning of solid waste, coal combustion and mining are the activities behind mercury (Hg) contamination of water. Also nickel contamination is from corroded metal pipes (Cempel and Nikel, 2006).

Contaminated soils by heavy metals is the most serious environmental issues that have impact on agricultural plant yield due to the adverse effects on food safety, marketability and crop growth due to phytotoxicity and environmental health of soil organisms (Asati *et al*., 2016). Increased amounts of heavy metals in soil and consequently, in forage and foodstuffs produces mutagenic, teratogenic, carcinogenic or toxic effects upon penetration into a living organism (Bashmakov *et al.,* 2005). Despite the fact that higher concentration of heavy metal may have a negative impact to the society, living organism (bacteria, fungi, plant, animals) still may require some of these elements in trace amount. Cadmium (Cd), chromium (Cr) and lead (Pb) are the heavy metals of most concern because they can affect human health even in small quantities.

Long-term use of both fertilizer and manure on the commercial farmland can lead to higher metal accumulation in the soil and plants. Long-term use of excessive chemical fertilizer and organic manures in the bare vegetable field and the greenhouse vegetable field contributed to the accumulation of heavy metals in the soil (Huang and Jin, 2008). Wangstrand *et al* (2007) reported that nitrogen fertilizers may increase Cd concentration in plants; even if the fertilizer does not contain significant level of Cd. Agricultural runoff contaminates the fresh water bodies. The use of fertilizers that are enriched with nitrogen decreases the dissolved oxygen in rivers and coastal areas which in turn affect the biota. Unlike pesticides they leached into the ground water, thereby polluting it. At present, overuse or misuse of fertilizers in agriculture contributes to environmental deterioration from nonpoint source pollution and is therefore of great concern nationally and internationally (Atafar *et al*., 2010).

The present work has been conducted to study the impacts of some heavy metals on the growth and development of selected vegetables (tomato, sweet pepper, carrot, cucumber) seedling. Vegetables are important ingredient of human diet which contains essential nutrients and trace elements (Kalpana, 2016). Due to the high concentration of dietary fiber, vitamins, minerals, especially electrolytes; and more recently antioxidants in fruits and vegetables, dietitians provides dietary advice on the consumption of fruit and vegetables (Slavin and Lloyd, 2012). Vegetables are taken both in cooked and raw forms by humans and animals. Vegetables not only provide both micro-nutrients and trace elements but also regulate and adjust pH in the process of digestion (Jolly *et al.,* 2013). It contains nutrients, which made them to be rich in vitamins, minerals, fibers and beneficial anti-oxidative effect. However, intake of heavy metal contaminated vegetables may pose a risk to the human health (Lawal and Audu, 2011).

2.0 MATERIALS AND METHODS

2.1 Plant Materials and Treatment Details

Seeds of Tomato (*Solanum lycopersicum)* UC-82B, Sweet pepper (*Capsicum annuum*) poivron yolo wonder, Cucumber (*Cucumis sativus*) space master 80 and Carrot (*Daucus carotta*

L.) touchon were obtained from the Abubakar Rimi market, Fagge Local Govermnent, Kano, Nigeria. Experiments were carried out at the Center for Dryland Agriculture (CDA), Bayero University Kano, Kano State, Nigeria. Hydroponic nutrient solution (developed by Hoagland and Arnon, 1938) was prepared using $Ca(NO_3)_2.4H_2O$, KNO_3, KH_2PO_4, $MgSO_4.7H_2O$ as macronutrients and H_3BO_3,$MnCl_2.4H_2O$, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, $Na_2MoO_4.2H_2O$ and Fe-EDTA as micronutrients. Metal stress were created by applying Cadmium (Cd), Copper(Cu), Zinc(Zn), Chromium(Cr), Nickel (Ni), Manganese(Mn), and Iron(Fe) in the form of Cadmium Chloride ($CdCl_2$), Copper (II) Sulphate ($CuSO_4.5H_2O$), Zinc Sulphate ($ZnSO_4.7H_2O$), Chromium III Chloride ($CrCl_3.6H_2O$), Nickel (II) Sulphate ($NiSO_4.6H_2O$), Manganese Chloride ($MnCl_2.4H_2O$) and Ferrous Sulphate ($FeSO_4.H_2O$). Four concentrations (20ppm, 70ppm, 120ppm, and 200ppm) of each metal solution were prepared using deionised water with a control without metal.

2.2 Soil Sample Collection and Pre-treatment

The soil samples were collected from ten different points along four diagonal transects with the soil auger from farmland in kwakwachi area of Kano State at 15cm depth. The sample (one composite sample from mixing four different samples) was air dried, crushed and sieved with 2mm sieve. All plastic containers used were washed with detergent solution followed by 20% (v/v) concentrated Trioxonitrate (IV) acid and then rinsed with water and finally with distilled water (Audu and Lawal, 2005).

2.3 Pot Experiment

Pot experiments were conducted in triplicate. Soil was kept soaked in 0.1% sulphuric acid (H_2SO_4) for 3days to remove the nutrients and continuously washed with water to remove the acid. Litmus paper was used to confirm the absence of acid. Each pot was filled with 1Kg of nutrient free sand. In each pot, eight seeds were sown on the sand beds and after germination, three healthy seedlings were allowed to retain. Later 10 day-old-vegetable seedlings were treated with sulfates of iron, nickel, copper, and zinc; chlorides of manganese, chromium and cadmium metals. 5 cm^3 of both nutrient solutions and various respective metals were applied to the pot at 2days intervals until the end of the experiment for 3 weeks.

On completion of third week, treated seedlings were uprooted carefully from the soil, washed with distilled water. The root and shoot length of both treated and untreated seedlings were measured and recorded at the end of the experiment.

2.4 Digestion of Plant Material

The fresh seedlings were oven dried at 70℃ for 48hours. Dried sample (root and shoot) was ground and sieved through 0.5mm mesh. Acid digestion method was used. The procedure consisted of digesting 100mg of sample, adding 4cm^3 HNO_3, and heating at 65^o C for 60 minutes, after which the temperature was increased to 120^o C for an additional 30 minutes. Next, 1.6 cm^3 of hydrogen peroxide was added, and the mixture was cooled to room temperature. The samples were filtered through whatman No. 42 filter paper, and the volume was made up to 50cm^3 with deionized water (Lara *et al.,* 2015). Quantification of Cd, Cr, Mn, Zn, Fe, Ni, and Cu was carried out using an atomic absorption spectrometer (AAS Model 900HPinAAcle). The data collected on different parameters were statistically analyzed using the Tukey test (Analystat software 1.6.50).

3.0 RESULTS AND DISCUSSION

3.1 RESULTS

Table 3.1.1 Concentration of Heavy Metals in Pre-Plant Soil

Elements	Mean concentrations (mg/kg)
Cadmium	0.8±0.04
Chromium	81.7±0.73
Copper	4.45±0.38
Iron	6455±6.66
Manganese	90.8±0.24
Nickel	12.25±0.24
Lead	8.6±1.21
Zinc	16.85±0.05

values are represented as mean ± standard deviation of triplicate results.

Table 3.1.2: Metals uptake in different parts of Carrot seedlings when grown under their different concentrations

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	85.5 ±8.85	55.5±14.35	82±12.35	101.5±17.40	108±8.20	32.5±1.05	119±7.30	116.5±5.40	133±3.50	183.5±8.20
Copper	37.5±0.95	24.0±1.95	30±0.25	25.0±1.20	37.0±0.25	28.5±0.65	27.5±1.25	40.0±1.25	59.0±0.60	48.5±1.15
Iron	516 ±17.96	645±8.95	601±0.35	869.5±55	853.5±5.50	713±1.50	952 ±7.30	1443±11.80	1728±5.25	2091±1.30
Manganese	75 ±1.00	97±0.45	84.5±0.70	91.0±0.75	103.5±0.05	187±1.05	88.5 ±0.60	106.5 ± 0.85	190 ±0.65	145.5±1.15
Cadmium	6.5±0.35	14.0±0.50	16.5±0.20	26±0.15	31.5±0.15	7.0±0.15	22.5±0.25	34.5 ±0.35	60 ±0.50	143.5±0.75
Nickel	47.5 ±5.15	49.0±1.45	54.0±0.70	62.5±1.75	86.0±3.65	49.0±1.50	55.5±0.90	76.5±0.65	94.5±1.50	127.5±0.90
Zinc	311 ±1.55	36.5±0.40	52.0±0.95	137.0±0.90	159.0±0.30	341.5±1.50	248±0.40	337.5±0.15	439.5±1.25	496±1.25

Table 3.1.3: Metals uptake in different parts of Sweet pepper seedlings when grown under their different concentrations

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	-10.0 ±9.00	76.9±5.00	92.5±4.30	69.0±9.85	167.5±13.40	2.0±20.05	18.5±13.75	78.5±26.10	94±23.50	52±6.10
Copper	16.0±2.00	6.5±1.05	9.5±0.70	9.5±0.25	29.5±1.75	44±2.60	53.5±1.15	48.0±1.25	74.0±1.55	57.5±1.95
Iron	419±2.55	526±2.40	387.5±0.40	518.5±2.15	430.0±4.65	1315±7.80	1120 ±7.80	2944±5.85	1081±3.60	1310±4.35
Manganese	30.5 ±2.55	77.5±3.15	171.0±2.00	317.5±1.30	494±0.30	47.5±1.10	181 ±1.65	270.5 ± 0.80	339.5 ±0.10	511 ±1.05
Cadmium	5.5±0.90	15.5±0.30	52.5±0.25	37.0±0.15	58.5±0.05	6.5±1.45	15.0±1.05	86.0 ±0.60	54.5 ±0.25	200.5±1.35
Nickel	48.5 ±3.40	51±0.80	34.0±1.25	88±0.40	106±0.60	58.0±1.10	93.0±1.85	119±1.30	104.5±2.45	106.0±2.05
Zinc	348.5 ±1.30	336.5±1.55	252.5±1.55	323.5±1.10	386.5±0.70	409.5±1.45	375.5±0.50	487.5±1.35	382.5±2.90	427±1.45

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.4: Metals uptake in different parts of Tomato seedlings when grown under their different concentrations

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	56.5 ±7.75	57.0±11.20	26±3.45	76.5±8.70	86.5±3.25	86.5±6.50	84.5±4.90	164.0±9.05	138.0±8.40	153.5±13.10
Copper	45±0.85	22.5±5.15	19.0±0.90	22.0±0.90	24.5±3.35	41.5±1.75	18.0±0.30	66.5±2.15	27.5±0.80	62.5±1.25
Iron	370±14.30	415.5±3.95	604.5±3.60	427.0±1.75	759.5±0.85	2495±17.90	1606 ±27.00	1793±11.70	3233±7.35	2639.5±17.0
Manganese	28.5 ±1.00	49.0±1.70	54.5±0.75	61.0±0.95	62±1.20	53.0±1.00	30.5 ±1.00	46.5 ± 1.55	50.5 ±1.80	54 ±1.65
Cadmium	4.5±0.25	6.5±0.25	10.5±0.25	43.0±0.55	23.5±0.30	4.0±0.30	6.0±0.40	23.0 ±0.80	28.5 ±0.85	88±0.55
Nickel	49.5 ±1.00	56.0±4.15	55.0±0.70	49.5±3.25	69.5±4.00	45±2.50	39.5±1.85	60.0±2.20	71.5±1.25	83.5±2.55
Zinc	74.0 ±0.45	367.0 ±0.90	303.0±1.30	307.0±1.60	422.5±0.50	107.5±1.45	597±33.95	432±23.55	428.5±3.55	408.5±0.30

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.5: Metals uptake in different parts of Cucumber seedlings when grown under their different concentrations

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	-66.5 ±9.40	30.0±3.25	93.5±3.40	79.5±3.00	100.5±8.10	35.0±11.35	255.5±32.80	105.5±29.00	180.5±23.45	114.5±29.95
Copper	0.5±0.90	28.0±0.20	32.0±2.25	62.5±1.80	100.5±1.10	73.0±40.75	25.0±0.95	44.0±0.90	50.5±0.80	71.5±0.55
Iron	217±1.85	508.5±3.15	791.0±2.05	830.5±1.35	860.0±1.10	970.5±29.85	643.0 ±14.60	1716.5±23.30	1970±17.10	2205.5±58.05
Manganese	29.0 ±0.85	48.5±0.50	54.0±0.75	68.0±0.30	167.5±1.25	79.5±3.00	66.5 ±5.65	66.0 ± 7.10	115.0 ±4.55	184 ±6.05
Cadmium	5.5±0.25	27.5±0.50	29.5±0.35	84.0±0.35	115.0±0.55	15.0±1.90	17.0±2.65	46.5 ±0.55	86.5 ±0.90	85.5±0.65
Nickel	17.5 ±1.30	49.0±2.10	81.5±2.30	84.0±2.00	213±4.05	25.5±12.50	41.0±2.85	73.0±3.45	85.0±2.60	146±2.30
Zinc	469.0 ±0.60	98 ±0.70	104.5±0.15	141±0.80	136.5±0.85	258.0±1.85	116.5±1.00	128.5±1.25	97.0±0.25	366±2.10

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.6: Effect of different metals concentrations on shoot (mm) and root (mm) length of carrot seedlings

ELEMENTS	**SHOOT**					**ROOT**				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	20.0 ±1.20	22.0±1.60	18.0±0.60	16.0±0.50	15.0±0.40	14.5±0.50	14.0±0.40	11.3±0.40	10.2±0.30	9.8±0.20
Copper	20.0 ±1.20	20.9±1.30	18.2±0.70	19.0±1.00	17.5±0.50	14.5±0.50	16.5±0.60	13.2±0.40	10.8±0.30	11.0±0.30
Iron	20.0 ±1.20	16.0±0.40	19.0±0.80	17.0±0.50	17.2±0.50	14.5±0.50	13.5±0.40	11.7±0.30	10.8±0.30	9.4±0.20
Manganese	20.0 ±1.20	17.0±0.50	20.0±1.00	19.0±0.80	18.2±0.60	14.5±0.50	17.5±0.70	13.5±0.40	10.2 ±0.20	10.6 ±0.30
Cadmium	20.0 ±1.20	19.1±1.00	18.7±0.70	17.0±0.50	16.5±0.50	14.5±0.50	16.0±0.50	12.5±0.30	8.6 ±0.20	7.9±0.10
Nickel	20.0 ±1.20	21.0±1.60	18.0±0.60	17.0±0.50	14.5±0.30	14.5±0.50	13.5±0.40	12.7±0.30	11.8±0.30	11.5±0.40
Zinc	20.0 ±1.20	21.5±1.50	20.5±1.40	17.0±0.60	15.0±0.40	14.5±0.50	15.0±0.50	12.5±0.40	11.0±0.30	10.5±0.20

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.7: Effect of different metals concentrations on shoot (mm) and root (mm) length of sweet pepper seedlings

ELEMENTS	**SHOOT**					**ROOT**				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	19.5 ±1.80	19.8±1.70	12.0±1.00	14.0±1.20	11.1±0.80	10.5±1.00	11.0±1.20	8.5±0.60	6.2±0.50	7.9±0.40
Copper	19.5 ±1.80	16.0±1.40	15.2±1.30	14.1±1.20	11.9±0.90	10.5±1.00	9.2±0.90	11.3±1.30	7.0±0.40	7.5±0.40
Iron	19.5 ±1.80	10.7±0.50	13.6±1.10	13.5±1.00	11.2±0.80	10.5±1.00	11.7±1.30	6.8±0.40	10.5±0.90	8.7±0.60
Manganese	19.5 ±1.80	16.7±1.30	15.6±1.20	13.5±1.10	12.2±0.90	10.5±1.00	11.0±1.10	9.0± 0.80	8.7 ±0.50	7.6 ±0.40
Cadmium	19.5 ±1.80	14.8±1.30	11.6±0.90	13.1±1.10	9.0±0.40	10.5±1.00	11.3±1.10	8.0 ±0.70	9.1 ±0.90	5.7±0.20
Nickel	19.5 ±1.80	14.4±1.30	17.9±1.40	13.5±1.00	11.5±0.70	10.5±1.00	10.0±0.90	8.5±0.60	10.2±1.00	9.3±0.60
Zinc	19.5 ±1.80	18.3±1.60	18.5±1.60	16.3±1.30	15.0±1.40	10.5±1.00	13.5±1.40	9.4±0.70	10.0±1.10	9.0±0.80

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.8: Effect of different metals concentrations on shoot (mm) and root (mm) length of tomato seedlings

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	21.1 ±1.20	19.2±0.80	23.0±1.50	20.3±1.20	18.2±0.80	11.3±0.40	12.7±0.60	9.0±0.30	10.2±0.30	9.7±0.30
Copper	21.1 ±1.20	21.0±1.00	25.0±1.70	22.1±1.20	16.5±0.50	11.3±0.40	15.0±0.80	11.0±0.30	12.1±0.40	10.3±0.30
Iron	21.1 ±1.20	23.2±1.40	19.8±1.00	20.3±1.00	14.3±0.50	11.3±0.40	12.5±0.60	11.2±0.30	8.5±0.20	10.1±0.40
Manganese	21.1 ±1.20	25.1±1.80	21.2±1.10	20.4±1.00	19.6±1.10	11.3±0.40	11.5±0.40	11.0±0.50	10.2±0.30	9.6 ±0.20
Cadmium	21.1 ±1.20	20.5±1.10	18.2±0.90	13.8±0.40	15.8±0.50	11.3±0.40	13.0±0.60	12.1±0.50	11.0±0.50	9.0±0.30
Nickel	21.1 ±1.20	18.5±0.80	18.0±0.70	22.0±1.40	18.3±0.70	11.3±0.40	13.0±0.60	11.2±0.40	10.5±0.30	9.6±0.30
Zinc	21.1 ±1.20	17.5±0.60	21.8±1.20	18.5±0.80	16.0±0.50	11.3±0.40	8.0±0.20	11.0±0.40	10.6±0.30	10.8±0.30

Values are represented as mean ± standard deviation of triplicate results.

Table 3.1.9: Effect of different metals concentrations on shoot (mm) and root (mm) length of cucumber seedlings

ELEMENTS	SHOOT					ROOT				
	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg	Control	20mg/kg	70mg/kg	120mg/kg	200mg/kg
Chromium	13.5±0.60	12.3±0.50	9.6±0.30	12.5±0.50	7.8±0.20	19.0±1.00	16.2±0.70	19.0±1.00	17.0±0.70	18.5±0.90
Copper	13.5±0.60	13.0±0.50	11.5±0.40	10.2±0.40	8.8±0.20	19.0±1.00	22.5±1.20	21.0±1.00	18.8±0.80	16.0±0.60
Iron	13.5±0.60	13.0±0.40	11.0±0.40	9.5±0.30	9.3±0.30	19.0±1.00	21.0±1.10	18.0±0.80	17.3±0.70	13.5±0.40
Manganese	13.5±0.60	13.1±0.50	10.6±0.30	11.0±0.40	9.7±0.20	19.0±1.00	22.0±1.20	19.5±1.00	18.0±0.80	15.5±0.40
Cadmium	13.5±0.60	11.1±0.40	10.0±0.40	9.2 ±0.30	8.6±0.20	19.0±1.00	18.3±0.80	17.4±0.60	16.3±0.50	16.0±0.60
Nickel	13.5±0.60	13.5±0.60	12.5±0.40	12.0±0.40	10.8±0.30	19.0±1.00	21.0±1.10	19.0±1.00	16.0±0.60	15.1±0.50
Zinc	13.5±0.60	14.5±0.70	13.6±0.60	11.3±0.40	10.6±0.50	19.0±1.00	18.7±0.90	17.2±0.70	18.0±0.80	14.5±0.50

Values are represented as mean ± standard deviation of triplicate results.

3.2 Discussion

Mean and standard deviation of the metals in the soil is presented in table 3.1.1. The occurrence of heavy metals in the soil were found to be in the order: Fe> Mn > Cr > Ni > Zn> Pb > Cu> Cd. The result revealed the concentrations of heavy metals in the soil were within the recommended maximum levels as stipulated by National Environmental Standards and Regulations Enforcement Agency (NESREA, 2021) and World Health Organization/Food and Agriculture Organization (WHO/FAO, 2001). The mean concentration obtained for Fe was observed to be higher than 5000 mg/kg recommended by WHO/FAO (2001).

The present investigation showed that the mean concentrations of Zn, Fe, Cr, Cu, Ni and Mn in the roots and shoots of carrot, sweet pepper, tomato and cucumber seedlings increased in accumulation at 20 mg/kg, 70 mg/kg, 120 mg/kg, and 200 mg/kg of metals salts stated above were applied to the soil with respect to control (Table 3.1.2 - 3.1.5). This might be due to the increased in metal concentration of the soil. All findings cited have shown that elevated levels of metals in soil may lead to increased uptakes by plants. Khaled and Muhammad (2016), reported that heavy metal concentrations in plants grown in waste water irrigated soils were significantly higher than in plants grown in the reference soil. Alloway and Davies (1971);Grant and Dobbs (1977) suggest that plants grown on soils possessing enhanced metal concentration may have increased metal ion content.

The mean concentration of Iron (Fe) in carrot, sweet pepper, tomato and cucumber (root and shoot) parts has higher metal uptake than other metals across the soil treatments. This could be due to higher accumulation of Fe in the soil use for the experiment as shown in table 3.1.1 Ohki (1984) also observed that mean levels of Mn in wheat tissues increased as Mn supply in the soil was increased.

The concentration of metals in the roots is higher compared to the shoots of most vegetable seedling used for the research. This could be due to the fact that heavy metals come in contact with roots of plants first before translocation to the other parts. This result supports the theory that Odjegba and Fasidi (2006) reported in regards to high concentrations of metals in plant roots compared to other parts due to root been the first contact with heavy metals. Similarly, root ability to have a higher concentration of metals compared to the stems and leaves were observed (Zhao and Duo, 2015; Juen *et al*., 2014).

Carrot root in table 3.6 showed a significant decrease at 200 mg/kg cadmium treatment when compared with other metals. This might be attributed to its high metal accumulation at the root thereby effecting cell division and cell expansion. Doncheva *et al*., (2005), found that a decrease in mitotic activity has been reported in several plant species after exposure to heavy metals, which suppressed root growth. In addition, Abo-Kassem *et al.,* (1997) suggested that the root and shoot dry weight and relative growth rate on wheat were significantly reduced by Cd. Cadmium accumulation also reduced the shoot and root length of sweet pepper and tomato seedlings (Tables 3.1.7 – 3.1.8) including the shoot of cucumber seedling (Table 4.1.9) at 200 mg/kg as compared to control. This could be attributed to the toxic nature of cadmium even at low concentration and impaired metabolism. Gill *et al* (2012); Zhao *et al*., (2021); Anwaar *et al*., (2014) reported that accumulation of Cadmium within plant organs negatively interfere with essential physiological processes and plant growth. Plant photosynthetic organs and structures were damaged by Cadmium stress, which could explain the reduction in seedling growth (Fuzhong *et al*., 2010). In addition Cd stress affects plant mineral uptake by limiting the acquisition of essential minerals (Cengiz *et al*., 2020), leading to stunt plant growth.

It was found that copper treatment in low concentration at 20 mg/kg increased the length of tomato root and cucumber root respectively. This could be due to its role in activating some enzymes that are required for growth processes. This analysis supports the theory of Reichman (2002) that significant increase in the plant growth due to copper in trace amount.

4.0 Conclusion

This study revealed that the selected vegetables (carrot, sweet pepper, tomato, and cucumber) differ in their uptake capacity for essential and non essential metals (Zn, Fe, Cu, Cr, Cd, Ni and Mn). The research clearly showed that increased metal uptake by plants resulted due to higher concentrations of heavy metals in the soil. Cadmium is the most toxic metal for seedling growth of the tested crops. Sweet pepper seedling had the highest sensitivity for the tested metals compared to other plants. All the selected plants were sensitive to higher concentrations irrespective of the metals, resulted to inhibition of the vegetative growth (shoot and root).

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