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Effect of Cadmium and Zinc on growth and Biochemical Parameters of Selected Vegetables.

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Heavy metals occur naturally in soil but more is being released into the environment by humans especially from mining. Heavy metals are helpful for plants in mineral nutrition but in excess they cause pollution and are harmful for plants, invertebrates and some vertebrate fishes. Through precipitation of their compounds or by ion exchange into soil heavy metal pollutants can localize and lay dormant. They have inhibitory effects on plant growth and the performance of photosynthetic apparatus of plants. The present paper reports the adverse effects of zinc and cadmium on growth and biochemical parameters of Lady's finger and Cluster bean.

*Keyword:*Heavy metals, Zinc, Cadmium, Germination, Biochemical Parameters

1. Introduction

Heavy metal pollution can arise from many sources but most commonly arises from the purification of metals, e.g., the smelting of copper and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium.

Some of them are dangerous to health or to the environment (e.g. mercury, cadmium, lead, chromium), some may cause corrosion (e.g. zinc, lead), some are harmful in other ways (e.g. arsenic may pollute catalysts). These may also be carcinogenic or toxic, affecting, among others, the central nervous system (manganese, mercury, lead, arsenic), the kidneys or liver (mercury, lead, cadmium, copper) or skin, bones, or teeth (nickel, cadmium, copper, chromium).

Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation. One of the largest problems associated with the persistence of heavy metals is thepotential for bioaccumulation and bio magnifications. The sensitivity of plants to different heavy metals varies.

Zinc has several applications in industries, used in batteries, pennies, dies and casting for cars. It occurs naturally in soil but enters in the environment as the result of human activities, such as mining, purifying of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes. Although zinc is an essential requirement for good health, excess zinc can be harmful. The free zinc ion in solution is highly toxic to plants, invertebrates, and even vertebrate fish.

Plants use zinc in synthesis of chlorophyll, it is a component of protein, but in areas where soil is contaminated by zinc, only certain plants can grow as plants do not have a good way to dispose off these metals, they are harmful for earthworms

and microorganisms. Vegetables and other crops may be sensitive to zinc levels.

Cadmium is an extremely toxic metal commonly found in industrial workplaces, is used extensively in electroplating, industrial paints, manufacture of some types of batteries. Exposures to cadmium are addressed in specific standards for the general industry, shipyard employment, construction industry, and the agricultural industry.

2. Materials and Methods

The seeds of lady's finger (*Abelmoschus esculentus* L.) and cluster bean (*Cyamopsis tetragonoloba* L.) were treated with increasing concentration of zinc sulphate and cadmium chloride solutions. The experiment was conducted in petriplates for a period of 7 days along with control. The seeds were washed with distilled water and dried with blotting paper. The pre-sterilized petriplates were lined with filter paper. Three replicates were taken for each respective concentration. 5-10ml of solutions and distilled water was added to each petri plates on 1st, 3rd, 5th and 7th day of treatment. The petri plates were kept in natural light.

Germination percentage was recorded after 48 hours. Fresh weight was recorded after 7 days. Then, seedlings were wrapped in labeled blotting paper, oven dried at 80' c for 24 hours and dry weight was recorded. Then water content was estimated.

To study the effect of zinc sulphate and cadmium toxicity on growth and biochemical characteristics of lady's finger and cluster bean, the experiments were carried out during rainy season. The earthen pots (11 inches) were filled with sandy-loamy soil. Three replicates were taken for each respective concentration.

Toxic concentration of zinc sulphate ($ZnSO_4$) and cadmium chloride ($Cdcl_2$) solutions was applied to the pots in the form of irrigation water at regular times and in equal quantity. Plant samples were harvested after 15 and 30 days following sowing of seeds then, they were washed gently with water to remove the adhering particles. Then, they were studied for various morphological characters, these included root length (cm), shoot length (cm), biomass determination (gm), number of leaves and leaf area (cm^2).The chlorophyll content of leaves was estimated by Arnon's method (1949) at each harvest. Soluble protein content was estimated in leaves by Bradford's method (1976) using bovine serum albumin as standard.

3. Results

Table 1 shows the effect of increasing concentration of Zn on percentage germination, growth and biochemical parameters of seedlings of lady's finger. At 25 ppm $ZnSO_4$ concentration, there was increase in percentage germination, but there was steady decrease beyond it. At 100 ppm Zn concentration, there was 62.71% reduction in percentage germination compared to control and there was no growth in seedling, so measurement was not possible.

Table 2 shows the effect of increasing concentration of Cd on seedlings of lady's finger. There was steady decrease beyond the control. At 5ppm Cd concentration, there was 88.23% reduction in percentage germination compared to control and there was no growth in seedling, so measurement was not possible.

Table 3 shows the effect of increasing concentration of Zn on Cluster bean .There was no such effect on percentage germination. At 20 ppm concentration, there was increase in fresh weight, total chlorophyll and carotenoids, but there was steady decrease in these parameters beyond this concentration.

Table 4 shows the effect of increasing concentration of Cd on Cluster bean. There was no visible effect on percentage germination. At 0.5ppm $CdCl_2$ concentration the reduction in fresh weight was by 72.29% (0.087 gm) and total chlorophyll by 57.14% (0.006gm).

Table 5 shows the result of pot experiment using toxic concentration of $ZnSO_4$ and $CdCl_2$ on lady's finger after 15 and 30 days of sowing (1st and 2nd harvest).

At 100ppm $ZnSO_4$, there was significant decrease in fresh weight of root (by 42.23%&38.97%), fresh weight of shoot (by 43.86% &56.73%) and dry weight of root (by 50.94%) ; compared to their respective control sets. At 5ppm

concentration of $CdCl_2$ there was significant decrease in growth and biochemical parameters of lady's finger.

Table 6 shows the result of pot experiment using toxic concentration of $ZnSO_4$ and $CdCl_2$ on cluster bean after 15 and 30 days of sowing (1st and 2nd harvest).

At 50ppm $ZnSO_4$, there was significant decrease in fresh weight of root (by 41.17%&47.95%), fresh weight of shoot (by 36.24%&33.12%) and dry weight of root (by 34.78%) ; compared to their respective control sets. At 0.5ppm concentration of $CdCl_2$ there was significant decrease in growth and biochemical parameters of cluster bean.

Table 1: Effect of zinc and cadmium on percentage germination (after 48hours):

Zinc	Control	25ppm	50ppm	100ppm	250ppm	500ppm
48 hrs	86.2%	88.4%	62%	32.14%	6.25%	0%
Cadmium	Control	0.1ppm	0.5ppm	1ppm	5ppm	10ppm
48 hrs	85%	83.3%	66.6%	60%	10%	0

Chlorosis and necrosis after 5th day

Table 2: Effect of zinc and Cadmium on seedling growth and biochemical parameters of lady's finger after 7 days of sowing:

Zinc	**Control**	**25ppm**	**50ppm**
Fresh weight gm/plant	0.5594	0.5974	0.246
Water content	46.42%	48.44%	15.44%
Total chlorophyll (mg/gm)	0.069	0.077	0.047
Carotenoids	0.010	0.023	0.008
Cadmium	**Control**	**0.1ppm**	**0.5ppm**
Fresh weight gm/plant	0.3852	0.355	0.238
Water content	43.89%	43.66%	40.28%
Total chlorophyll	0.062	0.059	0.033
Carotenoids	0.018	0.020	0.051

Table 3: Effect of zinc and cadmium on percentage germination (after 48 hours):

Zinc	Control	20ppm	25ppm	50ppm	75ppm	100ppm
48hrs result	100%	100%	100%	100%	64%	30%
Cadmium	Control	0.1ppm	0.5ppm	1ppm	5ppm	10ppm
48hrs result	97.7%	95.5%	93.3%	93.3	86.6%	0%

Table4: Effect of zinc and cadmium on seedling growth and biochemical parameters of cluster bean after 7 days of sowing:

Zinc	Control	20ppm	25ppm	50ppm
Fresh weight gm/plant	0.338	0.375	0.299	0.195
Water content	49.11%	8.75%	7.69%	
Total chlorophyll	0.0145	0.0147	0.040	0.038
Carotenoids	0.0089	0.0088	0.0072	0.0032
Cadmium	Control	0.1ppm		0.5ppm
Fresh weight gm/plant	0.314	0.128		0.087
Water content	50%	10.1%		2.2%
Total chlorophyll	0.014	0.012		0.006
Carotenoids				

Table5: Effect of zinc and cadmium on growth and biochemical parameters of lady's finger after 1st and 2nd harvest (15 and 30 days):

15days	**Root length (cm)**	**Shoot length (cm)**	**no. of leaves**	**Leaf area (cm^2)**	**Fresh weight of root (gm)**	**Fresh weight of shoot (gm)**	**Dry weight of root (gm)**	**Dry weight of shoot (gm)**	**Total chlorophyll (mg/gm)**	**Total pro(mg/gm)tein**	**Total protein**
control	3.2 ±0.38	15.8±0.75	4.2±0.28	10.68	0.0644±1.82	0.807±1.83	0.053±0.01	0.288±0.02	0.014	0.589	0.589 ±
zinc	3±0.37	13.4±0.67	3.6±0.20	8.066	0.0372±1.82	0.453±1.08	0.026±0.02	0.180±0.03	0.010	0.500	0.500 ±
cadmium	2.5±0.29	10±0.42	2.2±0.38	4.1	0.0346±1.81	0.210±1.04	0.015±0.01	0.073±0.03	0.002	0.311	0.311 ±

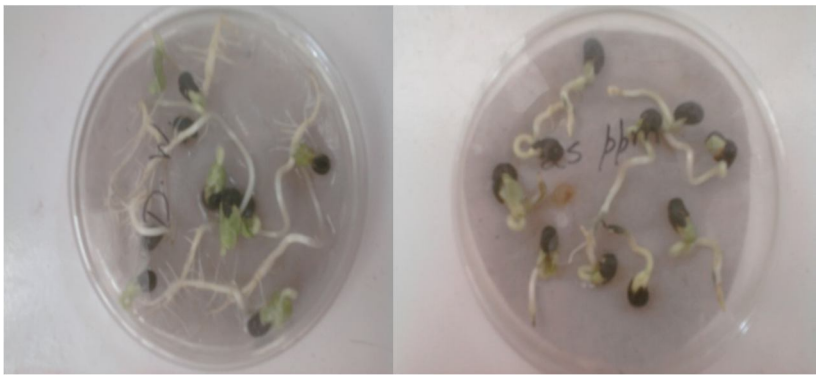
30days	**Root length (cm)**	**Shoot length (cm)**	**no. of leaves**	**Leaf area**	**Fresh weight of root (gm)**	**Fresh weight of shoot (gm)**	**Dry weight of root (gm)**	**Dry weight of shoot (gm)**	**Total chlorophyll**	**Total protein**
control	9.3±0.37	30.9±0.76	6.4±0.22	59.54	0.857±0.241	4.720±0.82	0.042±0.01	0.394±0.04	0.020	0.713
zinc	8.1±0.64	27.4±0.57	3.4±0.26	45.42	0.643±0.200	2.042±0.73	0.032±0.01	0.362±0.04	0.015	0.619
cadmium	7.4±0.23	19.3±0.64	2.3±0.16	20.55	0.350±0.199	1.285±0.70	0.030±0.02	0.244±0.05	0.008	0.312

Table 6: Effect of zinc and cadmium on growth and biochemical parameters of cluster bean after 1st and 2nd harvest (15 and30 days):

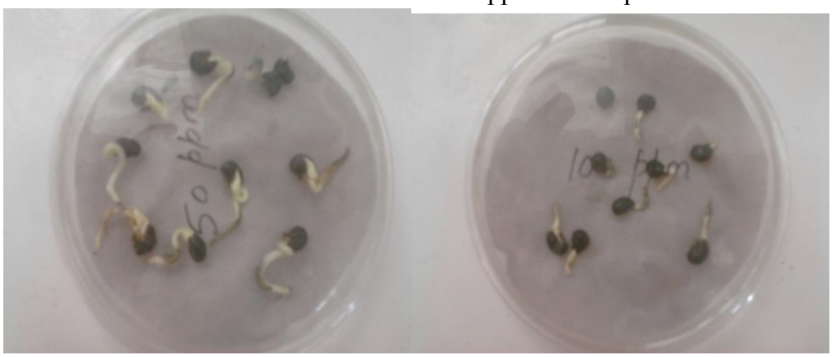
15days	**Root length (cm)**	**Shoot length (cm)**	**no. of leaves**	**Leaf area**	**Fresh weight (gm)**	**Fresh weight of root (gm)**	**Fresh weight of shoot (gm)**	**Dry weight of root (gm)**	**Dry weight of shoot (gm)**	**Total chlorophyll (mg/gm)**	**Total protein (mg/gm)**
control	4.9	12.7	3.6	6.02`	0.762	0.068	0.298	0.023	0.140	0.616	0.326
zinc	4	10.2	3	4.08	0.680	0.040	0.230	0.020	0.129	0.414	0.314
cadmium	3	7.3	2.2	3.2	o.340	0.029	0.145	0.018	0.096	0.203	0.126
30days	**Root length (cm)**	**Shoot length (cm)**	**no. of leaves**	**Leaf area**		**Fresh weight of root (gm)**	**Fresh weight of shoot (gm)**	**Dry weight of root (gm)**	**Dry weight of shoot (gm)**	**Total chlorophyll**	**Total protein**
control	6.4	14.40	5	10.20		0.098	0.388	0.040	0.290	0.640	0.392
zinc	6.1	12.62`	4.2	7.02		0.051	0.300	0.039	0.243	0.428	0.322
cadmium	4.0	8.0	2.0	4.22		0.029	0.210	0.024	0.202	0.322	0.197

Seed Germination and Seedling growth experiments

Abelmoschus esculentus

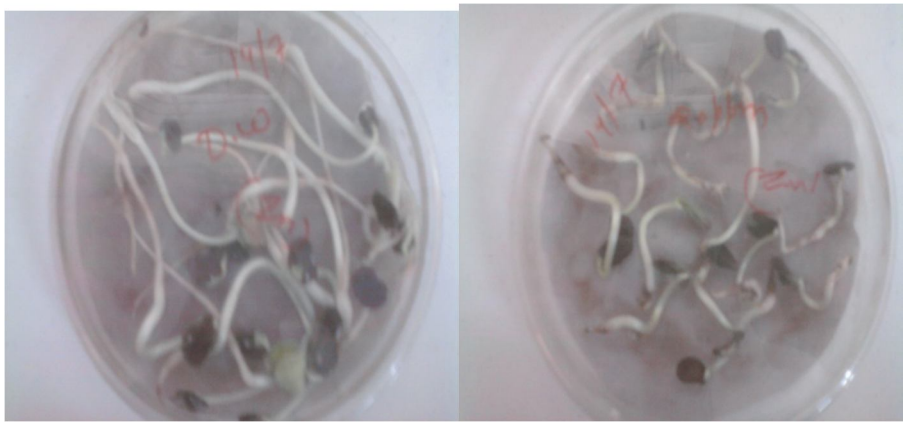


Distilled water 25 ppm zinc sulphate

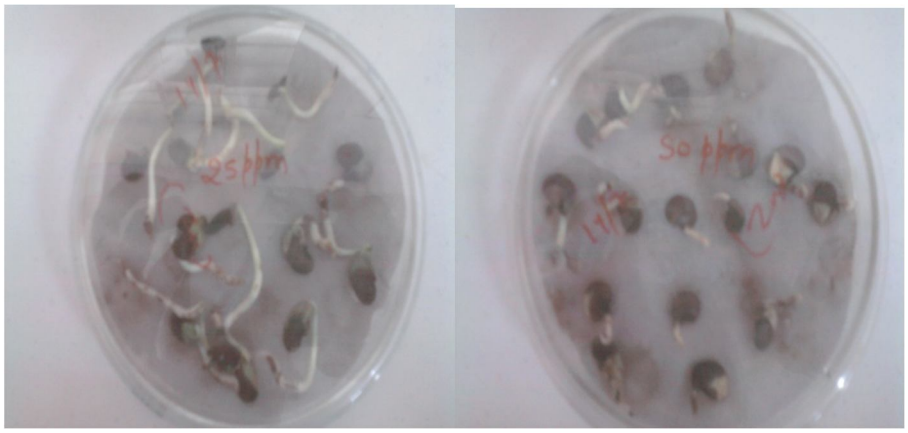


50ppm zinc sulphate 100 ppm zinc sulphate

Cyamopsistetragonoloba

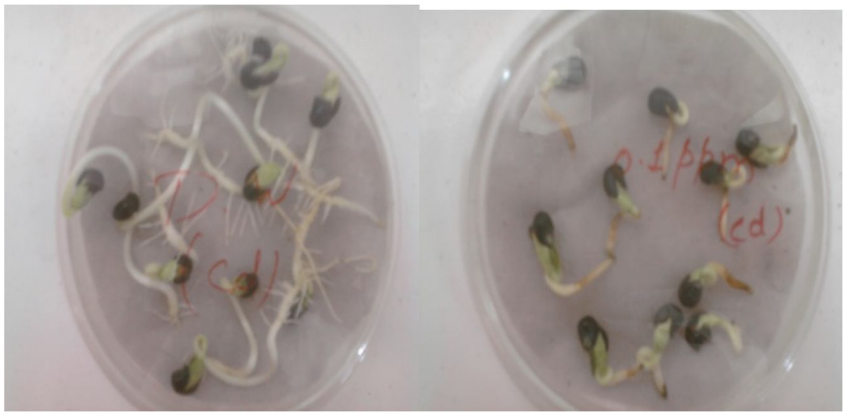


Distilled water 20 ppm zinc sulphate

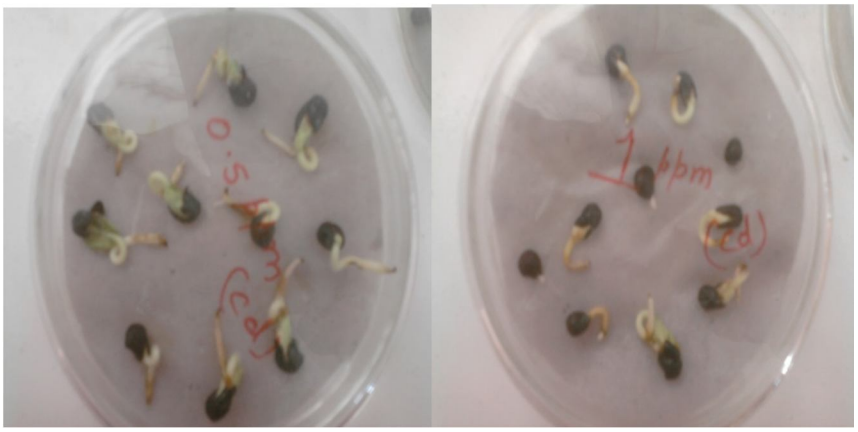


25ppmzinc sulphate 50 ppm zinc sulphate

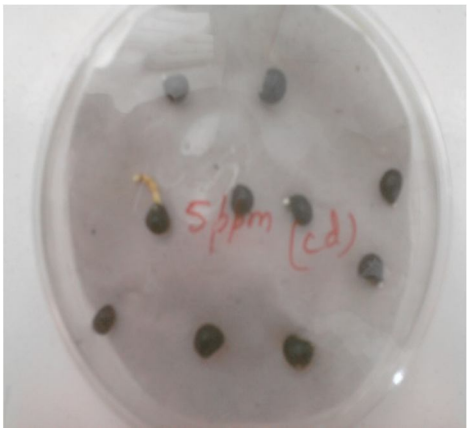
Abelmoschus esculentus



Distilled water 0.1 ppm cadmium chloride

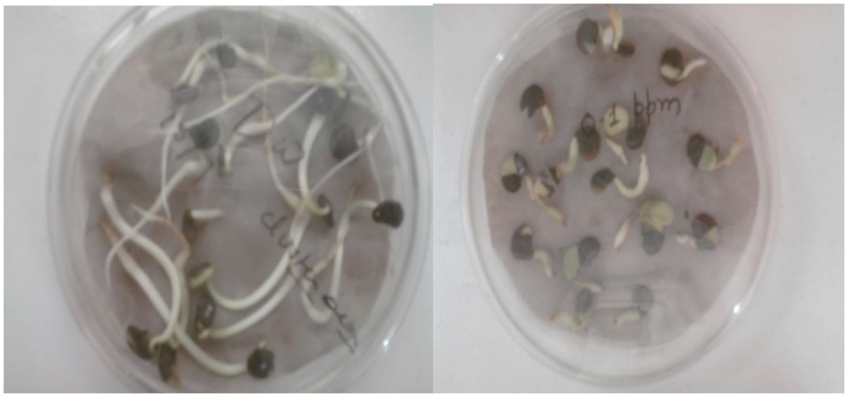


0.5ppm cadmium chloride 1 ppm cadmium chloride

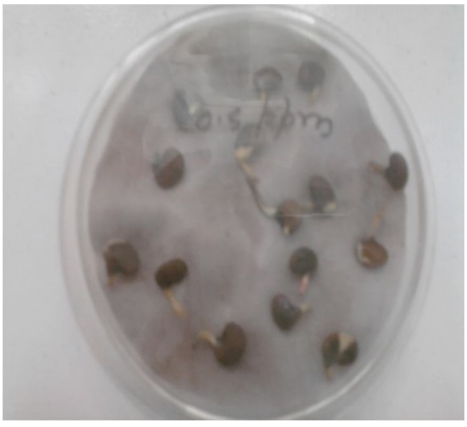


5ppm cadmium chloride

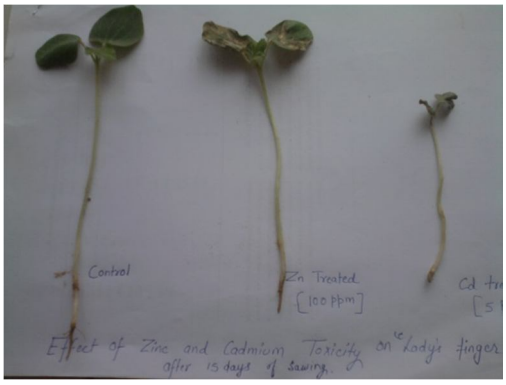
Cyamopsis tetragonoloba



Distilled water 0.1ppmcadmium chloride



0.5ppm cadmium chloride



Cyamopsis tetragonoloba (After 30 days)

Control

0.5ppm cadmium chloride treatment

4. Discussion

The Zinc concentration beyond 50 ppm causes significant decrease in seed germination, fish weight, total chlorophyll and carotenoids in *Abelmoschus esculentus* and *Cyamopsis tetragonoloba* (Table1-4).This is in agreement with Vassilev et al (2011) decrease in fresh mass, leaf area, net photosynthetic rate, transpiration, stomatal conductance, rate of apparent photosynthetic electron transport and isoprenoids accumulation in *Phaseolus vulgaris* L. cv. Lodi plants.

Table1-4 also shows decrease in seed germination beyond 1ppm and reduced biochemical parameters beyond 0.1ppm of cadmium in both experimental plants.Ghani (2010) showed similar studies in 7 mung bean varieties .Horler et al (2008) conducted experimental work on pea

plants to study the heavy metal toxicity. They found that most general effects of Cd, Cu, Pb or Zn were growth inhibition and decreased.

Table5, 6 shows results of high concentration of $ZnSo_4$ and $CdCl_2$ after 15 and 30 days on both plants. There was significant decrease in growth and biochemical parameters.Dong et al (2005), Wang and Zhou (2005), Rascio et al (2002) and Tuna et al (2002) showed similar results.

Dong et al (2005) studied the effect of cd on growth of tomato seedling and found reduced plant height, root length and root volume as compared to control.

Wang and Zhou (2005) studied toxic effects of cd on three ornamental plants. They exhibited of significant inhibitory effects on root elongation and shoot elongation.

Rascio et al (2002) studied the effect of cadmium toxicity on maize plant. These symptoms included length reduction of both roots and shoots, leaf bleaching, ultra structural alterations of chloroplasts and lowering of photosynthetic activity.

Tuna et al (2002) showed inhibition of growth of plumula and redicles at high concentration of heavy metals (10-200 ppm). Others adverse effects include decline in germination percentage, germination index, and root and shoot length, root and shoot dry matter rates.

Vassilev et al (1995) studied the effect of Cd stress by in a 12 days experiment of barley plants. The result suggested tendency towards decrease in photosynthetic rate.

Heavy metals released into the environment through difference sources including industries and affect our fauna and flora. Study of effect of zinc on growth and biochemical parameters of *Abelmoschus esculentus* and *Cyamopsis tetragonolobus* showed that zinc act as a nutrient till a certain concentration but adversely affects growth beyond,. cadmium is far more toxic , harmful at .5 ppm concentration.thus,not only the heavy metals vary in their toxicity ,the sensitivity of vegetables to heavy metal pollution also differs.thus,there is a need to monitor and control the heavy metal pollution due to increasing industrialization

5. Acknowledgement: Authors are thankful to Department of Science and technology, Jaipur, Rajasthan. For the financial Assistance.

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