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# Effect of Some Heavy Metals on Germination and Growth of *Zea mays* L

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**Abstract:**

The aim of this study was to determine the effect of heavy metals on germination and growth of Zea mays. Six concentrations (2,0, 1.5, 1.0, 0.5, 0.25, 0) mMol/ L of heavy elements, nickel, lead and cadmium were used. Germination and length of shoot and root system, as well as the fresh and dry weights of shoot and root for Zea mays. The results showed that the high concentrations of nickel and cadmium elements caused a significant reduction in the percentages of germination compared to the element of lead. Also, the high concentrations of heavy elements caused a reduction in both the length of shoot and root, fresh and dry weights for them, and the effect of lead was less than that of nickel and cadmium elements for all treatments.
**Keywords:** *Zea mays*, Germination, Growth, Heavy Metals

## Introduction:

Many plants are distinguished by their ability to absorb pollutants from the air, soil and water and accumulate them in their tissue cells in a way that does not cause any harm from them and thus have an important role in solving and treating environmental pollution in the places in which they grow) Panwar *et al.*,1999 ) . The risk of pollution grows steadily with the expansion of cities, the increase in population, and the large number of factories, as pollutants flow to all components of the ecosystem, causing soil, water and air pollution, and attempts to control pollution are often insufficient to stop it (Ibrahim, 2012). Heavy metals are considered to be dangerous environmental pollutants because of their ability to accumulate and stay in the soil for very long periods because they are not subject to dissolution and therefore they accumulate annually at different levels in the food chain and some of them are important in the metabolism and work of enzymes, but their presence in high concentrations is toxic or harmful to Living organisms and results in what is known as heavy metal poisoning (Haiyang *et al.*, 2015). The problem of contamination of field crops with heavy elements is one of the most important problems faced by developing countries as their presence in the soil leads to a decrease in the rate of plant growth (Vassilev, 2003). In addition to its effect on biological processes by inhibiting some vital processes, including photosynthesis and thus a decrease in its productivity (Kastori *et al.*, 1992). Zea mays is a yearly crop of monocots belonging to the Poaceae family, and is cultivated. In Iraq, with two times: autumn and spring, the cultivation of this crop is widespread in the governorates of Kirkuk and Babil (Central Statistical Organization, 2015). The seed germination and early growth stages are among the most sensitive stages to changing environmental conditions (Seregin and Ivanov, 2001). That is why the growth rate of seedlings at this stage is often used to assess the plant's tolerance to heavy metals, and because seed germination is the first physiological process affected by these pollutants. If the seeds were able to germinate in a medium containing one of the heavy elements, it would be a direct evidence of their resistance and tolerance to this element. (Peralta *et al.* 200). Heavy metals usually accumulate in the roots of plants as they are the plant organ most contacted and affected by them (Salt *et al;* 1995; Wojcik and Tukiendorf; 1999; Rout *et al*., 2001) and as a result of their toxic effect, the inhibition of root elongation was observed primarily through the effect on extension. Their cells are in the region of elongation or by the cessation of the division process in them (Fiskesjo, 1997) and that determining the length of the roots is an important and good indicator for knowing whether or not the plant tolerates the toxicity of the mineral (Piechalak et al., 2002; Belimov et al., 2003; Odjegba and Fasidi, 2004; Han *et al*., 2007). Heavy metals also have a great effect on the vegetative total of the plant, represented by the height of the stem. (1997) Rout et al., And that the decrease in its height may be accompanied by a decrease in the growth of the root, which affects the transfer of water and nutrients to the shoot of the plant (Shanker *et al*., 2005) The present study aims to follow up the effect of germination rates and the morphological changes that occur on *Zea mays* as a result of its treatment with different concentrations of some heavy elements, namely Ni, Pb and Cd due to the plant's economic importance.

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## Materials and methods:

### Determine the effectiveness of plant seeds:

I used the seeds of the maize plant, *Zea mays* L., Baghdad 3 variety, which was brought from the General Authority for Agricultural Research and Water Resources / Field Crops Community / Seed testing and Certification department located in Abu Ghraib / Baghdad. The effectiveness of the seeds was tested by taking (100) seeds from the plant seeds. And put them in a petri dish with a diameter of (15) cm that contains two filtering papers, and (15) $cm^3$ of distilled water were added and the percentage of germination was calculated, after 7 days of planting, and the percentage of seed germination was (97%).

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## Effect of heavy metals on germination:

### Preparation of heavy metal solutions

Heavy metals solutions were prepared from the salts of those metals, represented by nickel chloride $Nicl_2$, lead nitrate $Pb\ (No_3)_2$, and cadmium chloride $Cdcl_2$ with concentrations of (2.0, 1.5, 1.0, 0.5, 0.25) mMol / L, as shown in Table (1), In addition to distilled water as a control treatment.

**Table (1) : The concentrations of heavy metals used in the laboratory experiments**

| Metals | Chemical structure | Concentration mMol/L | gm/L |
|---|---|---|---|
| Ni | $NiCl_2$ | 0.25 | 0.0517 |
| | | 0.50 | 0.103 |
| | | 1.00 | 0.207 |
| | | 1.50 | 0.31 |
| | | 2.00 | 0.414 |
| Pb | $Pb(NO_3)_2$ | 0.25 | 0.0828 |
| | | 0.50 | 0.165 |
| | | 1.00 | 0.331 |
| | | 1.50 | 0.497 |
| | | 2.00 | 0.662 |
| Cd | $CdCl_2$ | 0.25 | 0.0342 |
| | | 0.50 | 0.0685 |
| | | 1.00 | 0.137 |
| | | 1.50 | 0.205 |
| | | 2.00 | 0.274 |

**Germination of seeds by adding heavy metal solutions:**

The seeds were planted in plastic plates with diameters of (14) cm by (100) seeds per dish with the addition of (7) $cm^3$ of distilled water for the control treatment, and (7) $cm^3$ of the different concentrations of heavy metals solutions (Pb, Cd, Ni). And represented by (2.0, 1.5, 1.0, 0.5, 0.25) mMol / L, at the rate of four replications for each treatment, and this was done after placing the seeds on a piece of gauze with filter paper to reduce evaporation. Then the number of seeds germinated after (7) days was calculated. By the following equation:

$$\text{Germination (\%)} = \frac{\text{number of seeds germinated}}{\text{The total number of seeds}} \text{x}100$$

Hydroponics for plants

The seeds were washed and planted in plastic pots containing a mixture of (soil - bitumen) in a ratio of 1: 1, so that (4) seeds were planted for each pot at a depth of (1) cm, taking into account the distance between the seeds, and with three replications in each plastic container for each treatment. Pots with distilled water for a period of two weeks until the seedlings grow and the roots come out from the bottom pot holes. Then the plastic containers were filled with a volume of (4) Litter of Hogland solution so that it reached the edge of the pot at a height of (1) cm. After a week, concentrations of heavy elements were added as shown. In Table (1) to Hogland solution (Table 2) in plastic containers and mixing them well, meaning that the plant was treated at the age of three weeks, and the nutrient solution mixed with concentrations of heavy elements was added periodically at the rate of twice a week in each plastic container by calculating the amount of water Missing and complete the volume to 4 L of Hogland solution

**Table (2): The chemical components of the Hogland solution used in plant cultivation**

| Stock solution | Chemical structure | Stock solution g/10 L | Concentration g/L |
|---|---|---|---|
| A | $KNo_3$ | 505 | 0.505 |
| | $CaNo_3$ | 1180 | 1.18 |
| | $NH_4No_3$ | 80 | 0.08 |
| | $KH_2Po_4$ | 68 | 0.068 |
| B | $MgSo_4\ 7H_2o$ | 493 | 0.493 |
| C | $FeSo_4.7H_2O$ + NaEDTA | 22.5 | 0.0225 |
| D | $H_3Bo_3$ | 2.86 | 0.00286 |
| | $Mncl_2.4H_2o$ | 1.81 | 0.00181 |
| | $ZnSo_4.7H_2o$ | 0.22 | 0.00022 |
| | $CuSo_4.5H_2o$ | 0.05 | 0.0005 |
| | $H_3MoO_4.H_2o$ | 0.12 | 0.0012 |

**Determine plant height:**

The height of the plant was determined by means of a metric strip inserted in (cm) from the bottom of the plant stem to the top for all plants and for all treatments, the plant height rates were recorded.

**Determine the length of the root system:**

The length of the root stock was determined by a metric bar from the beginning of the root to its top, for all plants and for all parameters.

**Determine soft weight and dry weight:**

The fresh weight of the vegetative and root groups was determined separately by a sensitive balance of type (Precisa XB 22 OA) for all treatments, while the dry weight was determined by a sensitive balance after placing the plant in an electric oven at a temperature of (70) m for three day

**Statistical Analysis**

All the analyses were conducted in triplicates. The heavy metals were evaluated with the Two-way ANOVA and L.S.D test using SPSS software (SPSS ver.23). *P*- values less than 0.05 were considered to be statistically significant.

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**Results and Discussion:**

**Germination of plant seeds:**

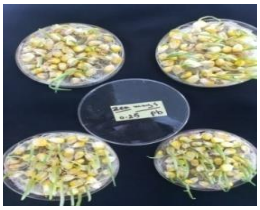
Table No. (3) shows the effect of the concentrations of heavy elements (Ni, Pb, Cd) and the overlap between them on the germination of plant seeds, as it was noticed that there was a variation in germination rates between the rates of the different elements, so the low rate was 89.27% for the cadmium element, while the high rate appeared 92.00 % in elemental lead. The results of the statistical analysis proved that there were no significant differences between the three elements. As for the effect of heavy elements treatments on germination rates, a discrepancy was observed between them, and it became clear that there was a decrease in germination rates with an increase in element concentrations and the low concentration rate was 80.88% when the treatment was (2.0) mMol / L, while the high concentration rate appeared. 97.3 % when dealing with control. The results of the statistical analysis proved that there were no significant differences between the treatments and the control treatment, as well as there was no difference between the two treatments

(2.0, 1.5) mMol / L. As for the effect of the interaction between the element and the treatments on germination, it was noticed that there were no significant differences between the treatments (1.50, 1.00, 0.50, 0.25) mMol / L and the control treatment for the elements of nickel and cadmium, while significant differences were observed between the two treatments (1.5) and 2.0 (mMol / L) compared to With the control treatment, no significant differences were observed between the two treatments (2.00, 1.50) mMol / L. As for the component lead, no significant differences were observed between the treatments compared to the control treatment. This is due to the fact that high concentrations of the element nickel are considered toxic to most plant species as they affect the activity of the enzymes Amylase, Protease and Ribonuclease, and thus disrupt the germination of seeds and the growth of many crops, including the corn plant, as well as its effect on the digestion and metabolism of food stored in the seeds such as proteins and carbohydrates upon germination of seeds. (Ahmad and Ashraf, 2011; Ashraf et al. 2011), the cadmium element may cause damage to the membranes and reduce the food reserve of total soluble sugars and amino acids that the fetus needs through inhibiting the metabolism and enzymes represented by alpha-amylase and invertases, as well as its leaching and accumulation in the seeds that may lead to the production of free radicals (Ahsan et al., 2007; Rahoui et al., 2010; Sfaxi-Bousbih et al., 2010; Smiri et al. 2011) and these results are consistent with his findings (Khalil and Fathi, 2019). As for the element lead, its being a toxic element in a very negative way, it is expected to affect germination, but what explains these results is that some plants have the ability to avoid pollution by drawing the lead element into the walls of the seed cells, which enables it to protect the internal parts These results are consistent with the findings of (Nasser, 2005), through his study on the germination of Arugula seeds *Eruca sativa*.

**Table (3): Effect of heavy metals on germination percentages**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 97.33 | a 93.33 | a 92.00 | a 91.33 | ab 84.33 | b 81.00 | a 89.88 |
| Pb | a 97.33 | a 95.66 | a 94.00 | a 91.66 | a 87.66 | a 85.66 | a 92.00 |
| Cd | a 97.33 | a 96.33 | a 91.66 | a 89.33 | ab 85.00 | b 76.00 | a 89.27 |
| Rate | a 97.33 | a 95.11 | a 92.55 | a 90.77 | ab 85.66 | b 80.88 | a 90.38 |

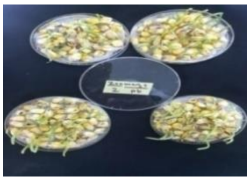
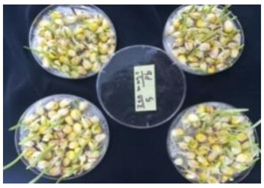
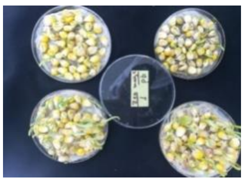
**L.S.D=14.68**


**Control**

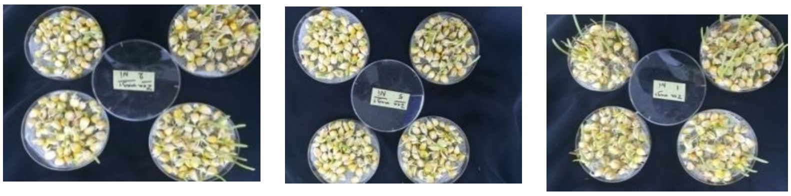
**0.5mMol/L** **0.25mMol/L**

**1.5 mMol/L** **2.00mMol/L** **1.00Mmol/L**

**Picture (1): Effect of Lead treatments on germination of *Zea mays* seeds**

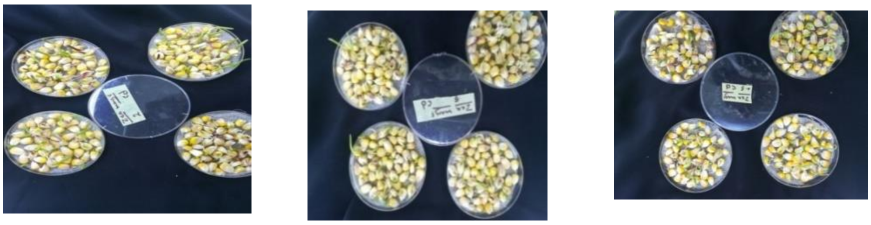
0.5mMol/L 0.25mMol/L Control



2.00mMol/L 1.50mMol/L 1.00mMol/L

**Picture (2): Effect of Nickel treatments on germination of Zea mays seeds**

0.25Mmol/L 0.5mMol/L Control



1.0mMol/L 2.00mMol/L 1.50mMol/L

**Picture (3): Effect of cadmium treatments on germination of Zea mays seeds**

**Effect of heavy metals on plant height:**

Table (4) shows the effect of the concentrations of heavy elements and the overlap between them on plant height, as it was noticed that there is a clear significant effect, as well as the variation in plant lengths between the rates of the elements themselves, as the low rate was (43.5) cm when cadmium element, while the high rate appeared (94.3) cm when Component lead. The results of the statistical analysis proved the presence of significant differences when treating the element lead, while no significant difference was observed between the two elements of nickel and cadmium.

The effect of heavy metals treatments on plant height rates, it was noticed that there is a clear discrepancy between them, and it appeared that there is a decrease in plant height with Increased concentrations of heavy elements. The low concentration rate was (40.0) cm when the treatment was (2.0) mMol / L, while the high concentration rate appeared (101.6) cm when the control treatment. The results of the statistical analysis also showed that there are significant differences between plant height rates at all treatments, but no significant differences were observed between the two treatments (0.5 and 1.0) mMol / L. As for the effect of the interaction between the type of element and the treatments on the characteristic of plant height, it was observed that there were significant differences between all the concentrations of the treatments with respect to the element of nickel, as for the element of lead, significant differences were observed between the concentrations of the treatments, but no significant differences were observed between the treatment and the control treatment ( 0.25) mMol / L, as well as between the two treatments (0.5 and 1.0) mMol / L, as for the cadmium element, significant differences were observed between the concentrations, but no significant difference was observed between the treatments (0.25, 0.5 and 1.0) mMol / L

**Table (4): Effect of Heavy metals on plant height**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 101.66 | b 57.33 | c 38.33 | d 32.00 | e 21.00 | e 19.00 | b 44.88 |
| Pb | a 101.66 | a 101.66 | b 97.00 | b 96.66 | c 88.00 | d 81.00 | a 94.33 |
| Cd | a 101.66 | b 40.33 | b 38.33 | b 37.00 | c 24.00 | d 20.00 | b 43.55 |
| Rate | a 101.66 | b 66.44 | c 57.88 | c 55.22 | d 44.33 | e 40.00 | 60.92 |

**L.S.D. = 3.69**

The reason for the decrease in plant height by increasing the concentrations of heavy elements is attributed to a decrease in the growth rate of plants, which led to its early stunting as a result of the accumulation of heavy elements in its parts, especially the roots, which caused the effect on the division of root cells and their elongation because the roots are considered barriers that impede the transfer of heavy elements to The upper parts of the plant, as well as the lack of readiness of water necessary for the growth of the plant, which led to a decrease in the height of the plant And it agrees with the findings of a study (Ullah *et al.*, 2020) on three types of chickpea, *Cicer arietinum* L.

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**Effect of heavy metals on the length of the roots:**

Table (5) shows the effect of the concentrations of heavy metals and the overlap between them on the length of the root system of the plant, as it was noticed that there was a clear discrepancy between the rates of the elements as the low rate was (30.2) cm for the element nickel, while the high rate for the roots appeared (37.5 cm) for the element lead . The results of the statistical analysis showed that there are significant differences between the element lead and the elements nickel and cadmium, while no significant differences were noticed between the elements of nickel and cadmium. As for the effect of the heavy elements treatments on the rates of root length, a clear discrepancy between them was observed, and there appeared to be a decrease in the length of the root system with Increased concentrations of elements. The low concentration rate was (25.7) cm when the treatment was 2.0 mMol / L, while the high concentration rate appeared (41.0) cm when the control treatment. The results of the statistical analysis showed that there were significant differences between the rates of the length of the root total for all treatments, but no significant difference was observed between the two treatments 0.25 and (0.5 mMol / L and the control treatment, as well as between the two treatments 0.5) and 1.0 mMol / L. As for the effect of the overlap between the element type and the treatments on the characteristic of the length of the root total, significant differences were observed between all the concentrations of the treatments with respect to the element of nickel, but no difference was observed between the two treatments (0.25) and (0.5 mMol / L). As for the element lead, differences were observed. Significant between the concentrations of the treatments, but no significant difference was observed between the control treatment and the two treatments (0.25) and (0.5

mMol / L, as well as between the treatments 0.5) and 1.0 and 1.5 (mMol / L), but with the cadmium element, significant differences were observed. Between the concentrations, however, no significant differences were observed between the two treatments (0.25 and 0.5) mmol / liter and the two treatments (1.0 and 1.5 mMol / L). And because the root is the first organ that faces heavy elements, it suffers a decrease in its length with an increase in the concentration of elements, and this is due to the inhibition of division Cells and their elongation and this is what previous studies indicated (Pena *et al.* 2012; Thounaojam *et al.*, 2012; Sundaramoorthy *et al.*, 2010) and their effect on plant hormone activity in roots exposed to heavy elements such as oxins (Souden and Zarinkamar, 2012)

**Table (5): Effect of heavy elements on the length of the root system**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 41.00 | b 35.33 | B 34.66 | C 31.33 | D 22.00 | e 17.33 | b 30.27 |
| Pb | a 41.00 | a 41.33 | B 37.00 | b 37.00 | bc 35.00 | C 33.00 | a 37.50 |
| Cd | a 41.00 | b 37.33 | B 37.00 | C 33.00 | C 32.00 | d 27.00 | a 34.66 |
| Rate | a 41.00 | a 38.00 | ab 36.22 | b 33.77 | C 30.11 | d 25.77 | 34.14 |

**. L.S.D.=3.42**

**Effect of heavy metals on the fresh weight of the shoot:**

Table (6) shows the effect of the concentrations of heavy elements and the overlap between them on the fresh weight of the vegetative total of the plant, as it was noticed that there was a clear discrepancy between the rates of the elements. The results of the statistical analysis showed that there are significant differences between the ions of the elements used in the study, the least effect of which was the element of lead. As for the effect of the treatments with heavy elements on the rates of the soft weights of the vegetative group, it was noticed that there is a clear discrepancy between them, and in general, there is a decrease in the soft weight. With increasing concentrations of elements. The average of low weight weight was 21.98 (gm) when the treatment was 2.0 mMol / L, while the average for the fresh weight was (169.93) gm when the control was treated. The results of the statistical analysis proved that there are significant differences between the averages of the weights of the shoots for all treatments. As for the effect of the overlap between the element type and the treatments on the lean weight characteristic of the vegetative total, it was observed that there were significant differences between all the concentrations of the treatments with respect to the elemental nickel, but no significant difference was observed between the two treatments (1.5 and 2.0) mMol / L, while the treatment for the element lead was observed. Significant differences were observed between the concentrations of all treatments, except between the two treatments (0.5 and 1.0) mMol / L.

**Table (6): Effect of heavy metals on the fresh weight of the shoot**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 169.93 | b 78.27 | c 52.29 | d 29.48 | E 4.95 | e 4.38 | b 56.55 |
| Pb | a 169.93 | b 115.43 | c 102.18 | d 72.01 | E 68.70 | f 49.84 | a 96.84 |
| Cd | a 169.93 | b 33.28 | c 30.61 | c 30.33 | D 17.31 | e 11.73 | C 48.86 |
| Rate | a 169.93 | b 75.66 | C 61.69 | d 43.94 | E 30.32 | f 21.98 | 67.25 |

**L.S.D=2.10**

Table (7) shows the effect of the concentrations of heavy elements and the overlap between them on the dry weight of the shoots, as it was noticed that there was a clear discrepancy between the rates of the elements. With element lead. The results of the statistical analysis showed that there are clear significant differences between the lead element and the two elements nickel and cadmium, while there is no significant difference between the elements nickel and cadmium. As for the effect of the heavy elements treatments on the dry weights of the vegetative group, it was noticed that there is a clear discrepancy between them, and it appeared that there is a decrease in Dry weight with increased concentrations of heavy elements. The low rate was (8.46) gm when the treatment was (2.0) mMol / L, while the high rate appeared (35.12 g) when the control treatment. The results of the statistical analysis showed that there were significant differences between the dry weights rates of the shoots for all treatments, but no significant differences were observed between the two treatments (0.5 and 1.0) mMol / L. As for the effect of the overlap between the element type and the treatments on the dry weight characteristic of the vegetative total, it was noticed that there are significant differences between all the concentrations of the treatments with respect to the elemental nickel, but no significant differences were observed between the two treatments (0.5 and 1.0) mMol / L, as well as between the two treatments (1.5 And 2.0) mMol / L, as for the treatments with the element lead, significant differences were observed between the concentrations of the treatments, but no significant differences were observed between the control treatment and the 0.25 treatment, as well as between the treatments( 0.5 and 1.0 and 1.5) mMol / L . As for the cadmium treatments, it was not noted. Significant differences were observed between the concentrations, but no significant differences were observed between the two treatments (0.5 and 1.0) mMol / L and the two treatments (1.0 and 1.5) mMol / L.

**Table (7): Effect of heavy elements on the dry weight of the shoots**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 35.12 | b 19.69 | C 8.61 | C 6.77 | D 2.00 | d 0.77 | B 12.16 |
| Pb | a 35.12 | a 37.14 | b 27.43 | b 26.94 | B 25.53 | C 21.86 | a 29.00 |
| Cd | a 35.12 | b 16.87 | C 8.37 | Cd 7.32 | D 5.61 | e 2.76 | b 12.67 |
| Rate | a 35.12 | b 24.56 | c 14.80 | c 13.68 | D 11.05 | e 8.46 | 17.94 |

**L.S.D=2.31**

Table (8) shows the effect of the concentrations of heavy elements and the overlap between them on the characteristic of the fresh weight of the root group, as it was noticed that there was a clear discrepancy between the rates of the elements. Element Lead: The results of the statistical analysis showed that there were significant differences between the three elements and was superior in the coefficients of the element lead. As for the effect of the treatments with heavy elements on the rates of the soft weights of the root group, it was noticed that there is a clear discrepancy between them, and it became clear that there is a decrease in the weight of the root total. With an increase in elemental concentrations, the low weight was (11.11) gm when the treatment was 2.0 mMol /L, while the average high weight was (41.25) gm when the control was treated. The results of the statistical analysis showed that there were significant differences between the rates of soft weights of the root total for all treatments, but no significant differences were noticed between the two treatments (0.25 and 0.5) mMol / L, as well as between the two treatments (0.5 and 1.0) mMol / L. As for the effect of the overlap between the element type and the treatments on the soft weight characteristic of the root group, significant differences were observed between all the concentrations of the treatments for the elemental nickel, but no significant differences were observed between the control treatment and the 0.25 mMol / L treatment. As for the coefficients for lead, differences were observed. Significant between the concentrations of the treatments, but he did not notice significant differences between the control treatment and the treatment (0.25) mMol / L as well as between the treatments (0.25 and 0.5 and 1.0) mMol / L. As for the cadmium element treatments, it was noticed that there were significant differences between the concentrations, but it was not noticed. There were significant differences between the two treatments (0.25 and 0.5) mMol / L and the two treatments (0.5 and 1.0) mMol / L

**Table (8): Effect of heavy metals on the fresh weight of the root group**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a 41.25 | a 40.23 | b 34.90 | c 27.87 | D 12.38 | e 7.45 | b 27.35 |
| Pb | a 41.25 | ab 39.21 | b 36.21 | b 36.62 | C 31.99 | d 18.43 | a 33.99 |
| Cd | a 41.25 | b 21.82 | bc 19.28 | C 14.91 | C 12.06 | d 7.44 | c 19.46 |
| Rate | a 41.25 | b 33.75 | bc 30.21 | C 26.47 | D 18.81 | e 11.11 | 26.93 |

**L.S.D=4.49**

**Effect of element concentrations on the dry weight of the root group:**

Table (9) shows the effect of the concentrations of heavy elements and the interaction between them on the dry weight characteristic of the root group, as it was noticed that there was a clear discrepancy between the rates of the elements. Component lead. The results of the statistical analysis proved that there were no significant differences between the three elements. As for the effect of heavy elements treatments on the dry weights rates of the root total, it was noticed that there is a clear discrepancy between them, and it became clear that there was a clear decrease with increasing concentrations of elements and the low concentration rate was (2.20) g when the treatment was (2.0) mMol / L, while it appeared the rate of high concentration (12.48) g when the control treatment, the results of the statistical analysis showed that there was no significant difference between the two treatments (0.5, 0.25) mMol / L and the treatments (2.0,1.5,1.0,0.5,0,25) mMol / L and the control treatment. As for the effect of the interaction between the element and the treatments on the fresh weight of the root total, it was noticed that there were no significant differences between the two treatments (0.25 and (0.5 mMol / L) and the control treatment for elemental nickel, but significant differences were observed between them and the treatments (1.0, 1.5 and 2.0) mMol / L. As for the component lead, it was noticed that there were no significant differences between the treatments (1.5, 1.0, 0.5, 0.25) mMol / L and the control treatment, while it was noticed that there were significant differences between each of the treatments (1.5) mMol / L and the treatment (2.0) mMol / L compared to the treatment. No significant differences were noticed between the two treatments (2.0, 1.5) mMol / L, with regard to cadmium element treatments, it was observed that there were significant differences between the control treatment and all the treatments, but no significant differences were noticed between the treatments, 1.5, 1.0, 0.5, 2.0) 0.25 mMol / L.

**Table (9): Effect of heavy elements on the dry weight of the root system**

| Metals | Concentrations Mmol/L | | | | | | Rate |
|---|---|---|---|---|---|---|---|
| | 0.00 | 0.25 | 0.50 | 1.00 | 1.50 | 2.00 | |
| Ni | a<br>12.48 | a<br>11.83 | a<br>10.24 | B<br>2.87 | B<br>1.42 | B<br>0.61 | a<br>6.57 |
| Pb | a<br>12.48 | a<br>13.49 | a<br>10.37 | A<br>8.43 | ab<br>8.67 | B<br>4.74 | a<br>9.70 |
| Cd | a<br>12.48 | b<br>4.28 | b<br>2.48 | B<br>2.30 | B<br>1.93 | B<br>1.25 | 4.12 |
| Rate | a<br>12.48 | bc<br>9.86 | bc<br>7.70 | C<br>4.53 | C<br>4.01 | C<br>2.20 | 6.82 |

**L.S.D=7.14**

The decrease in the fresh weights of the root and vegetative groups is due to the fact that heavy elements affect division, cellular expansion and hormonal regulation, as well as their influence on metabolic activities such as photosynthesis, respiration, building of nucleic acids, proteins, the activity of enzymes, etc. *Linum usitatissimum* L and (Subhy *et al.*, 2019) on *Triticum astivium*, and that the significant decrease in the dry weights of the vegetative and root groups is due to the negative effect of heavy elements in cell division and differentiation and root tissue damage as a result of the accumulation of high concentrations of these elements led to changes in Transport tissue and this is also in agreement with the findings of the study (Srinivas *et el.*, 2013). On the *Coccinia, Mentha* and *Trigonella* vegans

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