Physiological Response of Eruca sativa Plant Growing in soil Contaminated.

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Abstract
Two experiments carried out in department of biology in University of Mustansiriya to study response of *Eruca sativa* L plant planted in soil contaminated . The first experiment included planting_seeds in pitre dish that watered by water treated with heavy metal . The second experiment included planted in soil contaminated by, Cr, Ni , Al, and Pb, with three concentrations (0.01, 0.1, 1) mg/L . The results of the statistical analysis indicated that were significant differences, with registered highest germination percentage 83% % with treatment by Cr at a concentration of 0.01 mg/L. While lowest germination percentage was recorded 63.3% with treatment by Ni, at concentration 0.01 mg/l, compared with the control treatment which recorded 76.6%.The results of the statistical analysis showed that the element aluminum has an effect on the fresh weight of the shoot group, and that the highest average fresh weight of the shoot group achieved significant differences recorded (20.78) gm for the T4P1 treatment, and the lowest fresh weight of the shoot group achieved a significant difference recorded (18.20) gm for the treatment T4P3 compared to the treatment control T0P0. The results of the statistical analysis indicated that the highest fresh weight of the root under the influence of aluminum was (1.7) gm for the treatment T4P2 and the lowest fresh weight of the root was recorded (1.0) gm for the treatment T4P3, it did not reach the significant limits compared with the control factor, which recorded 2.0 gm. Aluminum affects root growth and inhibits the formation of secondary roots by inhibiting some acids such as salicylic acid.

Key words : Response , *Eruca sativa* , heavy metal , soil Contaminated

1. . Introduction

Heavy metals released into the environment pose a risk to organisms exposed to high levels of these pollutants. Minerals are essential for the biological functions of plants, but at elevated levels they interfere with metabolic reactions in living systems (Tekere, 2020). Metal stress is one of the largest abiotic factors limiting crop production worldwide. Plants face diverse environmental stresses broadly divided into abiotic and biotic stresses, heavy metal stress of which is one of the most harmful abiotic stresses, causing toxicity from By targeting biological processes in the plant cell (Siddhi *et al.*, 2013). *Eruca sativa* stands out as a biomarker for this type of plant. The green leafy plant has become a staple in a healthy diet, due to its high fiber content and also due to the presence of various micronutrients it contains. *Eruca sativa* is an annual herbaceous plant belonging to the cruciferous family (Brassicaceae). It originated in the Mediterranean and has been cultivated at least since the Roman and ancient Egyptian old (Sayad *et al.*, 2022).

2. . Materials and methods

2. 1 Collection of samples

The seeds of the Syrian *Eruca sativa* plant were selected from "Al-Mansour" (Engineering Agricultural Office).

2.2 Soil preparation for cultivation

Soil was taken at a depth of (0-30) cm from the surface near the Tigris River, Al-Grayat area in December 2022 and dried aerobically. / Laboratories of the Department of Biological Sciences in order to estimate a number of chemical and physical properties of soil before and after planting.

2. 3 Design of the experiment

The experiment was conducted as a practical experiment with two factors, the first factor, salts of heavy metals, including (Cr, Ni, Pb, and Aluminum Al) with three concentrations, each of them (1, 0.1, 0.01) mg. Liter.. *Eruca sativa* seeds were sown on December 6, 2021 in Petri dishes of 9 cm size, 10 seeds were added to each dish. With 3 replicates for all the elements under study from the concentrations used in the experiment (1, 0.1, 0.01) mg. Liter. Incubated at 25°C for 12 days. The second experiment was carried out in the field by planting seeds in plastic pots with a diameter of (23) cm and a height of (20) cm, and the capacity of each pot was (5) kg of soil. 4 kg of soil was added to each pot, and 10 seeds were planted in each pot, with 3 replications For all items used from the concentrations selected for the study, This

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experiment heavy metals were added to the plant. Each pot was irrigated with three concentrations (1, 0.1, 0.01) mg/L of. Distilled water control

2.4 Germination stage of Eruca sativa.

The number of germinated seeds was calculated daily, starting from the third day of sowing and for a period of 12 days, and the seeds were germinated when the roots appeared, up to a length of approximately 0.5 cm

2. 5 Seedlings of Eruca sativa

2. 5.1 Fresh weight of shoot and root

The seedlings were uprooted after 40 days from the date of planting, and the vegetative groups were separated from the root groups. Water spray and a sieve were used to prevent the loss of any part of the root, the shoot and root were weighed separately using a sensitive scale (gm)

2. 6. Physical analyzes of the soil.

2. 6. 1 Determination of soil texture.

The percentage of the volume distribution of soil particles was estimated by the density method given in

2. 6. 2. Measuring of pH

The degree of soil reaction was estimated using a pH meter using the previously prepared soil extract.

2. 6. 3. Electrical conductivity

Measured using an Electrical Conductivity Bridge using a 1:1 soil suspension extractor at 25°.

2. 7. Chemical analyzes of the crystal.

2. 7. 1. Measurement of organic matter.

Soil organic matter was determined by wet oxidation method.

2. 7. 2. The prepared nitrogen.

After nitrogen was extracted using a solution of potassium chloride (KCl) with a concentration of N2, the ammonium ion was estimated using magnesium oxide (MgO) by distillation after evaporation from the micro-caldal device, then reducing the nitrate ion through a Devarda alloy, then distillation with a Microclad device.

2. 7. 3. Ready phosphorous.

Prepared soil phosphorus was extracted using sodium bicarbonate 0.5 NaHCO, then the color of the extract was developed using ammonium molybdate and ascorbic acid. Phosphorus was estimated by a spectrophotometer at a wavelength of 882 nm according to Olsen's method mentioned.

2.7. 4. Ready Potassium.

Prepared soil potassium extract using ammonium acetate (CH3COONH3N1)) and estimated using a Flame Photometer as mentioned.

3. 3.Results and discussion

3.1 Effect of heavy metals on plants

The results in Table (3-1) showed that the highest germination percentage was 83.3% for Cr treatment at 0.01 mg concentration. liter. While the lowest germination percentage was 73.3% for the Cr treatment at concentration 0.1, which indicates that there are significant differences with the control factor, which recorded 76.7%. The seeds sprouted at low concentrations were similar to the seeds of the control plant, while the seeds at high concentrations were short and yellowish (Nasir *et al.*, 2020).

3.1.2 Effect of nickel on germination

The results in Table (3-1) indicated that the effect of nickel ions was negative on the germination process, as it showed the highest germination rate of 76.7% for the Ni treatment at a concentration of 1 mg.L, and the lowest germination percentage for the Ni treatment to 63.3% at a concentration of 0.01 mg. L. This indicates On the presence of significant differences with the control plant, which recorded 76.7%, this agrees with (Nasr, 2013).

3.1.3 Effect of lead on germination

The concentrations of lead ions pb had an effect on the number of germinated seeds as shown in Table 3-1, which was significant, as the highest percentage of germination reached 80.0% in the treatment pb at the concentration of 0.1,1 mg.L, which indicates the existence of significant differences as the percentage of germination It was higher compared to the control plant, which reached 76.7%, this agrees with Yuan *et al* (2015), and the lowest percentage of germination was 66.7% in the Pb treatment at a concentration of 0.01 mg L. This indicates that there were significant differences with the control plant, which amounted to 76.6%.

3.1.4 The effect of aluminum on the germination s

The results in Table 3-1 indicated that the highest percentage of germination was 80.0% for the treatment Al at a concentration of 0.1 mg. L, and the percentage of germination decreased to 70.0% at a concentration of 0.01 mg. L. This indicates that there were significant differences with the control plant whose value was 76.7%. The results agree with (JUAN *et al*, 2015).

Table (3-1) shows the percentage of germination under the influence of heavy elements

Transactions	Concentration			Average Transactions
	0.01 p1	0.10 p2	1 p3	
Cr	83.3	73.3	76.7	77.7 AB
Ni	63.3	70.0	76.7	70.0 C
Pb	66.7	80.0	80.0	75.6 B
Al	70.0	80.0	76.7	75.6 B
Control	76.7	76.7	76.7	76.7 B
average focus	72.2 b	74.4 b	78.2 a	

3.3 Effect of heavy metals in seedling stage

3.3.1 Wet weight of the shoot and root

system

The results indicated in Table (3-2), that the highest average fresh weight of the shoot was 20.78 g for the Al treatment at a concentration of 0.01 mg.L. The lowest fresh weight of the shoot was 18.20 g for the Al treatment, at a concentration of 1 mg. L. This indicates that there were significant differences compared with the control treatment, where the average fresh weight of the shoot was 16.92. This is in agreement with the results (da Silva et al, 2016). As results appeared in Table (3-3) the average fresh weight of the root, the highest fresh weight of the root was recorded at 1.7 for the treatment Al in concentrations of 0.1 mg.L, and the lowest fresh weight of the root was 1.0 compared with the control lab, which recorded 2.0. This indicates that there are significant differences with control plant, The toxicity of aluminum affects root growth, inhibits the formation of secondary roots, and leads to the emergence of a cracked sphenoid root.

The results in Table (3-2) showed that the highest average fresh weight of the shoot was 10.82 for Pb treatment at a concentration of 1 mg. liter and that the lowest average fresh weight of the shoot recorded 7.49 for Pb treatment at a concentration of 0.01 mg.L, which indicates that there are significant differences compared to the control plant, which scored 16.92%. This indicates that the Pb treatment did not reach the significant limits with the control treatment. This is consistent with (2019Sandra et al.,) who stated that lead encourages the process of oxidative stress in plants and thus inhibits plant growth. The results also showed in Table (3_3) that the fresh weight of the root in the treatment pb was 1.0 at the concentration of 0.01, 0.1, and 1, respectively, which indicates the presence of significant differences compared with the control plant, which scored 2.0. The toxicity of lead in roots may show an increased number of secondary roots per root unit, and it was reported (Jiang et al., 2010) about root swelling and loss of mitochondria from, vacuole. For the endoplasmic reticulum and dictosomes, injury to the plasma membrane and deep nuclei 48-72 hours after lead exposure to the roots of the plant used in the thresher.

The results indicated in Table(3-2)the effect of chromium on the fresh weight of the shoot system. The highest average fresh weight of the shoot appeared 20.70 for the Cr treatment at a concentration of 1 mg. L, and the fresh weight rate decreased to 11.05 for the treatment with Cr at the concentration, 0.1 mg.L, which indicates that There was a significant difference compared to the control plant, whose value was 16.92%. (Zied ,2001)

The results in Table 3-3 indicated that the highest fresh weight of the root was recorded at 2.0% for the Cr treatment at a concentration of 1 mg L. It is close to the control factor which recorded 2.0, so no significant difference was observed, while the root weight decreased by 1.0 in the 0.1 Cr treatment, which indicates that There were significant differences with the control coefficient, which scored 2.0. These results are in agreement with Tang et al, (2014).

The results showed in Table 3-2 the effect of nickel on the fresh weight of the shoot, that the highest value of the fresh weight was recorded at 18.78% for the Ni treatment at a concentration of 0.1 mg.L and the lowest fresh weight was recorded at 11.4 for the Ni treatment at the concentration. 0.01 compared with the control coefficient which scored 16.92 This is in agreement with (Hayyat *et al.*, 2020).The results in Table 3-3 showed that the highest value of the fresh weight of the root was recorded for the treatment Ni1.0 and in the Ultra under study 0.01, 0.1, 1 mg L, which indicates a significant difference with the control factor, which recorded 2.0 This is in agreement with Yuan et al (2015).

Table (3-2) shows the fresh weight of the vegetative mass

Transactions	Concentration			Average Transactions
	0.01	0.10	1	
Cr	11.32	11.05	20.70	14.36 B
Ni	11.48	18.78	12.63	14.29 B
Pb	7.49	11.69	10.82	10.00 C
Al	20.78	20.11	18.20	19.69 A
Control	16.92	16.92	16.92	16.92 AB
average focus	17.00 b	17.30 b	19.46 a	

Table (3-3) shows the soft weight of the root

Transactions	Concentration			Average Transactions
	0.01	0.10	1	
Cr	1.7	1.0	2.0	1.57 AB
Ni	1.0	1.0	1.0	1.00 B
Pb	1.0	1.0	1.0	1.00 B
Al	1.0	1.7	1.0	1.23 B
Control	2.0	2.0	2.0	2.00 A
average focus	1.93 a	2.08 a	1.89 a	

3.3 Characteristics of cultivated soil

3. 3.1 pH

The results of Table (3-4) indicated that there was a clear difference in the properties of the soil to which heavy elements were added separately compared to the control. 7.6 For Cr, the lowest soil pH value was 7.4 for Al. Ni compared to soil without addition, which recorded values of 7.2. The reason for the difference in pH values may be due to the association of elements with soil particles, which causes a decrease in soil basicity. This is consistent with what was mentioned (Gondal et al., 2021).

3.3.2 Electrical conductivity

The results recorded in Table (3-4) showed a difference in the conductivity ratio (EC) by adding heavy to the soil individually. The highest value was 1.74 for Pb treatment, and the lowest value was 1.51 for Ni compared to the control treatment, which was recorded by soil free of addition, which amounted to 1.07 amalgam. It agrees with what was mentioned (Sawicka *et al.*, 2021).

3.3.3 Soil organic matter (OM)

The results recorded in Table (3-4) showed the highest percentage of organic matter, which reached 0.86 g. kg-1 soil, in the treatment Pb, while the treatment Al recorded the lowest percentage, which is 0.62 g. kg-1 soil, while the control was 0.98 coefficient gave values all within the low range as a result of soil contamination from polluted water, as increasing the soil content of organic matter increases its ability to adsorb heavy metals. Organic matter (Hamid et al.,2020).

3.3.4 Nitrogen concentration

It is clear from Table (3-4) that the heavy elements added to agricultural soil caused a difference in the natural ratios of soil elements, including the percentage of nitrogen. Where the treatment Pb gave 34.5 mg / kg, which indicates the deposition of nitrogen in agricultural soil compared with the control, which recorded 32.2 mg / kg, (Alengebawy et al., 2021)

3.3.5 The concentration of potassium in the soil.

The results of Table (3-4) indicate that there was an increase in the potassium content of the soil used for planting watercress, where the highest value of the element was recorded, which amounted to 400 mg for the Ni treatment, where the potassium concentration was increased, and the lowest value was 197 mg for the Cr treatment when comparing these percentages with the recorded potassium value In the soil free of addition, which amounted to 133 mg, the increase of potassium in the soil may have caused an obstacle to the cultivated plants in absorbing some of the potassium in the soil.(Rehman et al.,2021)

3.3.6 Phosphorus concentration in soil.

The results of Table (3-4) showed that among the reasons that changed the properties of the agricultural soil with the addition of heavy elements is the change in the percentage of phosphorous with different concentrations, where the highest percentage of it was recorded in soil 1.59 mg for pb treatment, while the lowest percentage for phosphorus 0.64 mg for Ni treatment. The percentages are high because the soil without the addition was 1.52 mg of phosphorous. This increase may have caused a deficiency in some other elements, such as iron and zinc, which are affected by the phosphorous ratio, and the lack of these elements led to the disruption of some natural processes related to these or other elements (Al-Zubaidi, 2016).

Table (3-4) shows the estimation of heavy metals in cultivated soil

Soil texture and organic matter				Heavy elements and nutrients			pH and EC			
OM	Clay%	Silt %	Sand%	Elem ppm	Kppm	Pppm	N pphm	E Cdc Lcm	pH	العينة
0.86	7.3	7.8	84.8	.912	230	1.59	34.0	1.74	7.4	Pb
0.85	3.6	3.9	92.5	2.0	307	1.35	2.5	1.61	7.6	Cr
0.62	3.7	4.1	92.2	86.9	210	0.98	18.5	1.61	7.4	Al
0.67	3.3	3.7	93.0	1.05	400	0.64	15.4	1.51	7.5	Ni
0.98	3.7	3.9	92.4	1.52	133	32.6	32.2	1.07	7.2	Cont

4. 4-conclusions

By examining the results, we can conclude the following:

1- The heavy metals an effect on soil properties, including electrical conductivity, pH, and mineral nutrients.
2- Some heavy metals showed a positive effect on the germination rate, including chromium and aluminum oxide nanoparticles.
3- Some heavy metals showed a negative effect on the fresh weight of the vegetative and root system,
4-. Soil contaminated with heavy metals showed large numbers of bacteria that are resistant to pollution, and 10 types of bacteria were diagnosed by the VITEK2 system

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