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THE EFFECT OF DIFFERENT LEVELS OF LEAD ON THE VEGETATIVE AND ROOT GROWTH OF TAGETES ERECT L.

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Abstract

To study the effect of soil contaminated with four concentrations of lead (0, 150, 300, 450 mg kg^{-1}) on the vegetative and root growth characteristics. The results showed a significant decrease in the vegetative and root growth characteristics with an increase in lead concentrations, except for the diameter of the main stem of plants, which was not recorded. Any significant differences between the treatments,. In addition, lead contamination caused color paleness and then falling down of leaves as well as it caused coloring the roots in a dark brown color with decrease in their thickness.

Keywords: Tagetes erect L., lead, vegetative growth, and root growth.

1-Introduction:-

Marigold Tagetes erect L belongs to Asteraceae family, is one of the most important ornamental plants that used in the landscaping of natural places and as cut flowers due to their bright yellow and orange colors. (Nau, 1997), It is a one of the common summer annuals plants , and could be cultivated successfully in all parts of Iraq (Sultan et al., 1992). The plant is rich with essential oils that are used in the manufacture of perfumes, cosmetics, and other detergents. While residue oil in the distillation process is used as a flavoring agent in the pharmaceutical industry (Al-Shahat, 1988). Marigold is an ornamental plant, are grown for decoration and coordination, and to add aesthetics to the place in which they are located,
because they have a wide range of shapes, sizes, colors, leaves, and fragrances that suit a wide range of climates and landscapes, which include a wide range and different types of plants, including herbaceous and woody, including water and terrestrial, and those with high growth or low (Liu et al., 2007; Dobres, 2011).
The pollution of agricultural soils with various heavy metals is still one of the growing crises in different parts of the world, which has become a serious problem facing all countries including non-industrial and poor countries. During the last decade, industrial and agricultural activities have led to a significant increase in the concentration of heavy metals in the environment, especial in the soil (Adrees et al., 2015 ; Chien and kao, 2000). These heavy metals not only reduce plant growth and production, but they also pose a serious threat to human health through the food chain (Keller et al., 2015).

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It is known that heavy metals cause many toxic symptoms for plants, including damage to the cell membranes by causing a defect in their structure, inhibition of the photosynthesis process, inhibition of the action of enzymes, change in the stomata action , the flow of cations, the generation of free radicals, mess in cellular organelles resulting to poor physiological performance of plants which eventually causes growth retardation (Chen and Kao, 1995). Lead (Pb) is one of the major heavy metals that is considered a strong environmental pollutant due to its many direct and indirect effects on growth and metabolism of plant (Tomar et al., 2000), its effect specifically on root growth (Salt et al.,1995). Thus, expose the seedling to high level of lead caused greatly affects in roots development and vegetative growth (Fargasova, 1994). Eid et al.(2018) found that the effect of different concentrations of lead on the marigold plant revealed a significant decrease in plant height and number of branches with an increase in lead concentrations. The study of (Murti and Maryani, 2019) on the effect of some heavy metals on the Marigold plant showed a significant decrease in plant height, root length, and fresh and dry weight. The current study aims to determine the effect of different concentrations of lead that used by soil contamination on some characteristics of vegetative and root growth of Marigold plants, and whether these plants are suitable for cultivation in soil contaminated with lead.

2-Materials and Methods

The field experiment was conducted in the vegetable canopy at Agriculture College - University of Basra, during the agricultural season 2021-2022. To study the effect of different levels of lead on some characteristics of the vegetative and root growth of the Marigold plant, The seeds were sown in plastic pots with 10 cm diameter on 10/11/2021, post 21 day. the plants were transferred to 25 cm diameter plastic pots with 1:1 ratio of soil to peatmoss. Next, substrate was contaminated with lead acetate Pb $(CH_3COO)_2.3H_2O$ at concentrations (0, 150, 300, 450 mg kg^{-1}) as a source of pollution. Irrigation, fertilization, and weeding whenever needed, if the plants are fertilized with N-P-K neutral fertilizer (19, 19, 19) at a rate of 5 gmL^{-1} at a rate of 50 ml $Plant^{-1}$ at a rate of once a month until the beginning of flowering.

Table (1) shows some of the physical and chemical properties of the used peatmoss.

N	Traits	values
1	Electrical conductivity grade EC	0.445
2	Acidity number pH	6.2
3	The amount of moisture retention is	50%
4	Organic matter ($mgkg^{-1}$)	7.8
5	Nitrogen (mgL^{-1})	70 -160
6	Phosphorus (mgL^{-1})	70 -
7	Potassium (mgL^{-1})	80 -

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The traits studied include:

First: the characteristics of vegetative growth

1-Plant height (cm): The height of each plant of the experimental unit was measured from the surface of the soil to the top of the plant using a metric tape and the average was recorded for each treatment.

2-The number of leaves (leaf. plant^{-1}): The total number of leaves for each plant was counted and recorded their average. 3-Leaf area (cm^2): The leaf area was calculated by the gravimetric method, according to (Morsi et al., 1986), by selecting three leaves from each plant of experimental unit, then recording the weight of each leaf separately. 1cm^2 of square cut was cut from each and recorded its fresh weight .The average of three leaves calculation was recorded and leaf area index calculated according to the following equation.

$$\text{Leaf area} = \frac{\text{leaf weight (g)} \times \text{area of square cut (cm}^2\text{)}}{\text{weight of square cut (g)}}$$

The total leaf area of the plant was calculated according to the following equation: Total leaf area of plant = leaf area x total leaves. 4-Number of branches (branch plant^{-1}): All branches were counted of each plant and recorded their average. 5-Diameter of the main stem (mm): The diameter of the main stem of each plant was measured at a distance of 3 cm from the pot soil surface by using a Vernier Caliper and recorded their average. 6-Percentage of dry matter of the vegetative total (%): The percentage of dry matter in the leaves was estimated by taking the fresh weight of the leaves cut from the plants of the experimental unit and placed in an electric oven at a temperature of 70C° for a period of 48 hours and until the weight was stable, its dry weight was taken and the percentage of matter was calculated dry leaves according to the following equation:

$$\text{Percentage of dry matter of the shoot (\%)} = \frac{\text{The dry weight of the shoot}}{\text{Fresh weight of the vegetative group}} \times 100$$

Second: the characteristics of root growth.

The roots were separated from the shoots and washed well with running tab water, placed on filter paper to get rid of excess water droplets and dry a little, and then the physiological traits assessed as following:

1-Root length (cm): The longest roots of each plant in the experimental unit were measured by a metric tape from the connection area of root and stem to the end of roots with recording their average. 2-The number of roots (root plant^{-1}): The roots number of each plant was calculated and then recorded its average. 3-Roots diameter (mm): The diameters of five roots of each plant were measured using Verner Caliper, then their average was recorded. 4-The fresh

weight of the roots (g plant^{-1}): the fresh weight of the roots for each plant was recorded by using four level sensitive scale.

5-The dry weight of roots (g plant^{-1}): Roots were placed in an electric oven at 70°C for 48 hours and dry weight of roots recorded after the weight stability by four-level sensitive scale.

3-Statistical Design:

The experiment was designed using Completely Randomized Design (C.R.D) with one factor, four treatments, and each treatment had 3 replications. Then the results were analyzed using one-way ANOV, using the ready-made statistical program (Genstat 2013) to analyze the data of the studied traits, and the differences between the means were compared. Using the Least Significant Difference Test (L.S.D) at a probability level of 0.05 (Al-Rawi and Khalafallah, 2000).

4-Results and discussion:-

4-1: Effect of lead treatments on vegetative growth characteristics:-

4-1-1: plant height:-

The data of results indicated that the Control plants recorded the highest average (28.25 cm) in the plant height trait. However, the increasing in the plants height was not significant compared to treated plants with (150 and 300 mgkg^{-1}). While the lowest average (23.19 cm) was recorded in treated plants with (450 mgkg^{-1}) of lead acetate (Fig. 1).

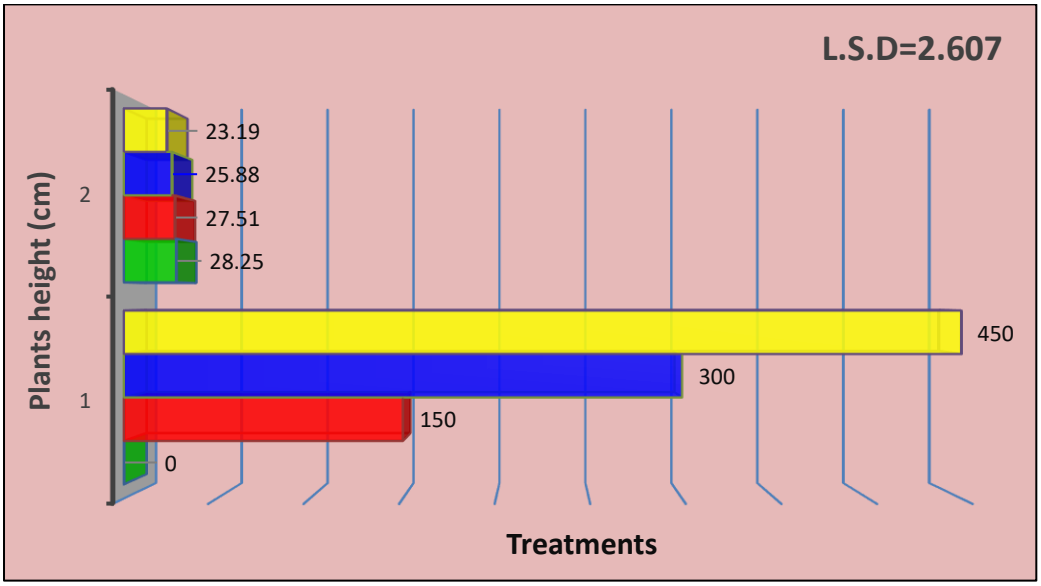

Figure 1 The effect of lead on plant height of Marigold (cm).

4-1-2: Number of leaves:-

The result showed that lead-untreated plants (control plants) was significantly superior compering to (300 and 450 mg kg^{-1}) treated plants in the number of leaves trait. However, plants that treated with 150 mgkg^{-1} of did not show any significant exceeding compered to the plants(Fig.2).

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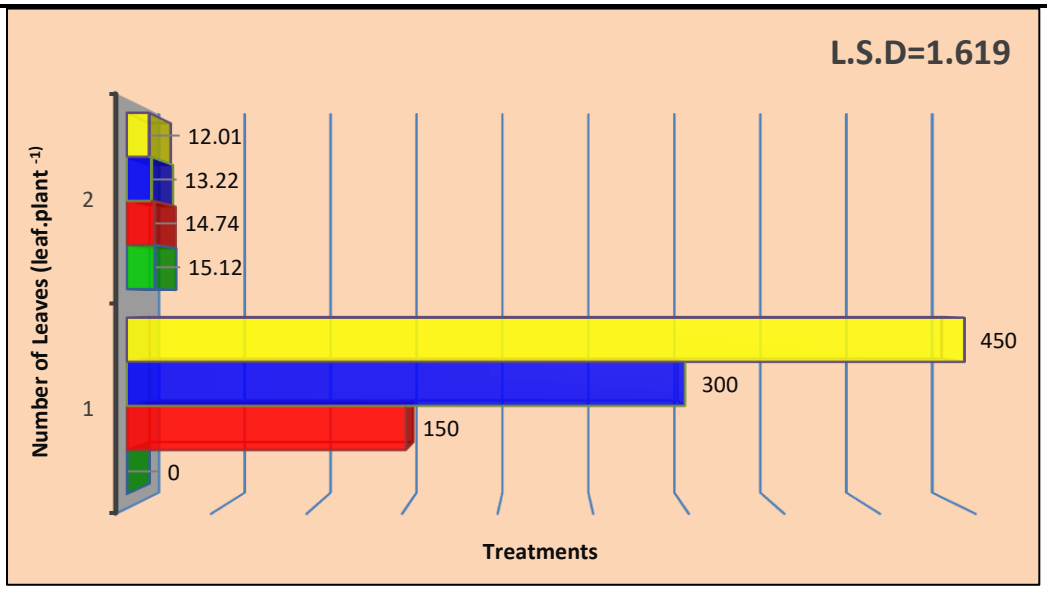

Figure 2 The effect of lead on the number of leaves of Marigold (leaf plant^{-1}).

4-1-3: leaf area:- It is noted from the result that the Control plants was significantly superior (71.22 cm^2) compared to the rest of treatments, except treated plants with 150 mgkg^{-1} in the average paper area,.While treated plants with (450 mgkg^{-1}) recorded the lowest average for this characteristic (67.11 cm^2) (Fig3).

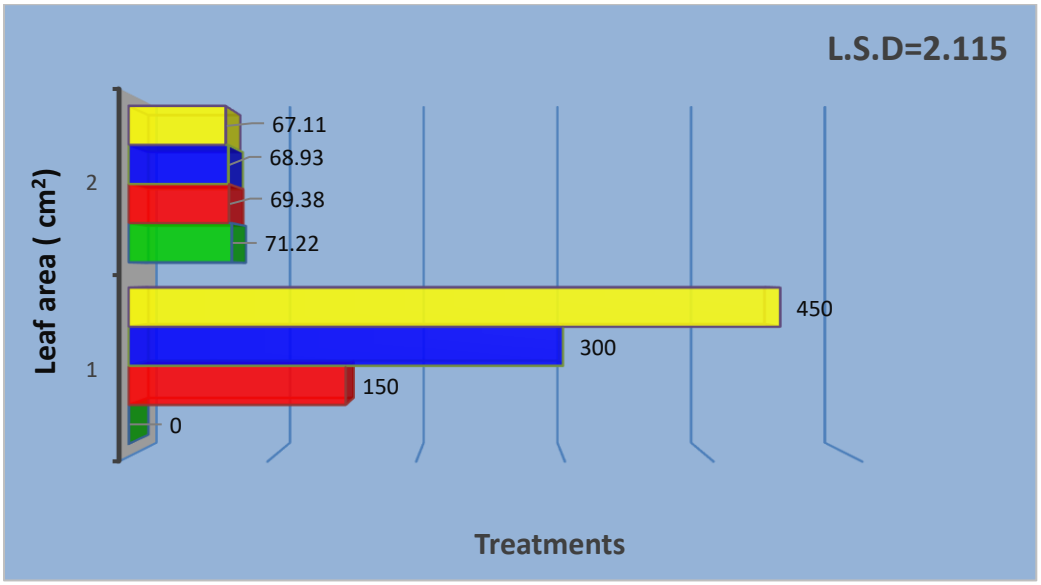

Figure 3 The effect of lead on the leaf area of Marigold (cm^2).

4-1-4: Number of branches:- Control plants recorded a high average in branches number trait (2.97 branch plant^{-1}) compared to treated plants with (450 mg kg^{-1}) that recorded a low average (1.71 branch Plant^{-1}) (Fig. 4).

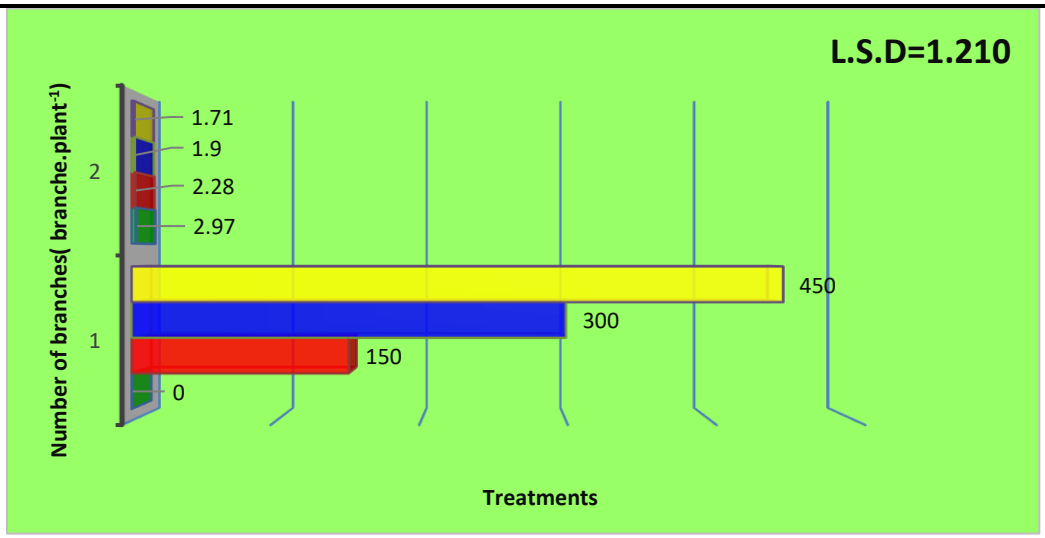

Figure 4 Tg effect of lead on the number of branches of Marigold (branch plant^{-1}).

4-1-5: Diameter of the main stem:- The results showed that the contamination with all lead acetate concentrations did not record any effect on main stem diameter of treated plants (Fig.5).

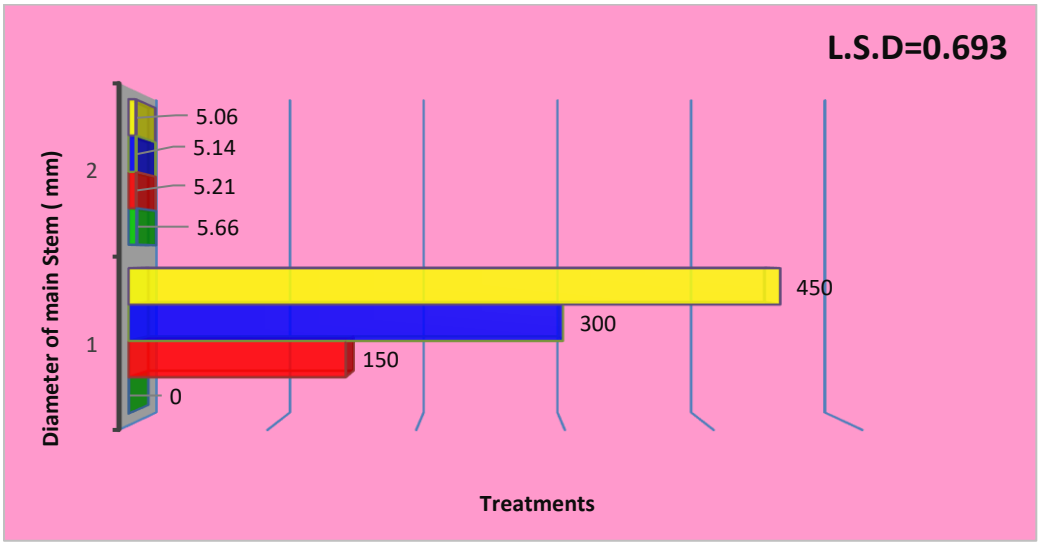

Figure 5 The effect of lead on the diameter of the main stem of Marigold (cm).

4-1-6: Dry matter leaves:-

The results of the statistical analysis showed that Control plants significantly exceeded in the average percentage of shoot dry matter by recording (15.88 %)

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comparening to (450 mg kg^{-1}) trearted plants that gave (9.99 %) (Fig. 6).

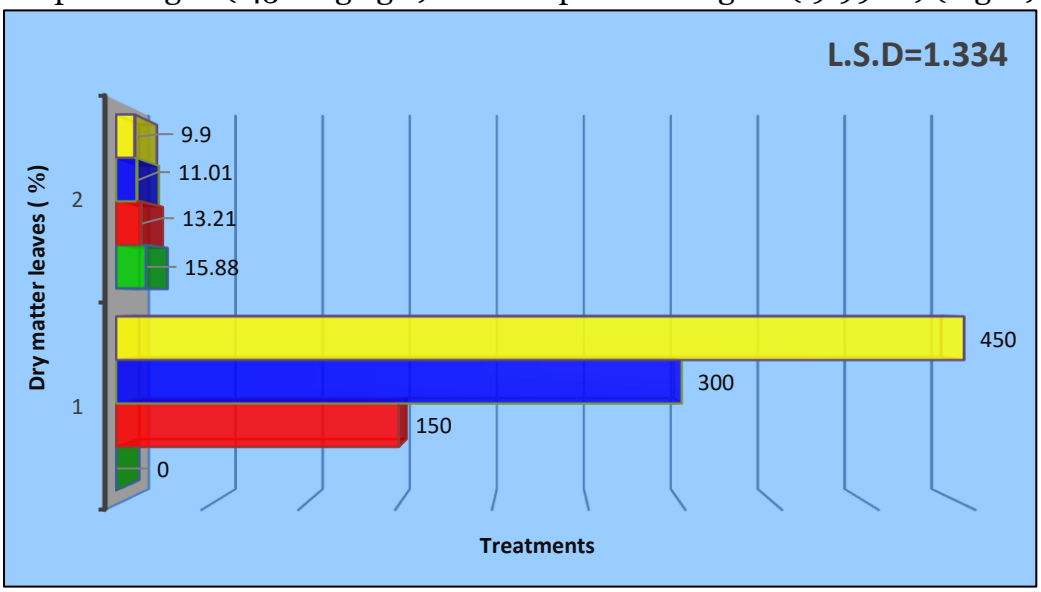
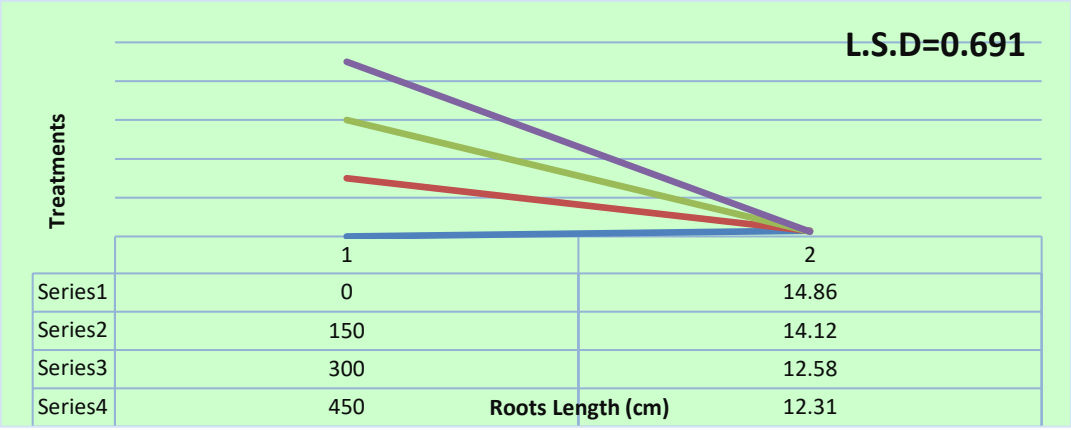


Figure 6 The effect of lead on the percentage of dry matter in the leaves of Marigold (%).

The obtained resultsin Figures (1, 2, 3, 4, 6) show the effect of different lead concentrations on the vegetative growth characteristics of the, i.e. plant height, number of leaves, leaf area, number of branches, and the percentage of dry matter of the shoot. Where the results showed a significant decrease in most of the studied vegetative growth characteristics with an increase in lead concentrations, except for the main stem diameter. The treatment with lead acetate at (450 mg kg^{-1}) concentration was the most harmful in all characteristics compared to the control treatment. Perhaps the reason behind that is the high lead concentration could cause roots damage and disturbance in the nutrients absorption resulting to plant growth reduction,. In addition, lead stress can inhibit or reduce the metabolism in the leaf area due to cell division disorders, as well as disturbances in the activity of some enzymes that are important in plant metabolism processes such as photosynthesis, respiration, and protein synthesis (Chaves et al., 2011). It is known that the stress of heavy metals leads to the emergence of symptoms of calcium deficiency as a result of disturbances in the process of calcium transport, as symptoms of calcium deficiency include curling or limping of small leaves or folding and total damage to the growth points (the leaf buds become semi-burnt), as well as affecting the color of the leaves that turn to Yellow color due to the breakdown of chlorophyll pigment (Rout et al., 2001). Obtained results agree with study result of (Murti and Maryani, 2019), which showed a significant decrease in the most of vegetative growth traits of when exposed to heavy metal stress. Previous study by (shah et al., 2017) about the effect of accumulation of different lead concentrations showed that there were no significant differences in the leaf area and height of Tagetes erecta L. However, a high lead concentrations led to a decrease in the level of all studied morphological indicators.

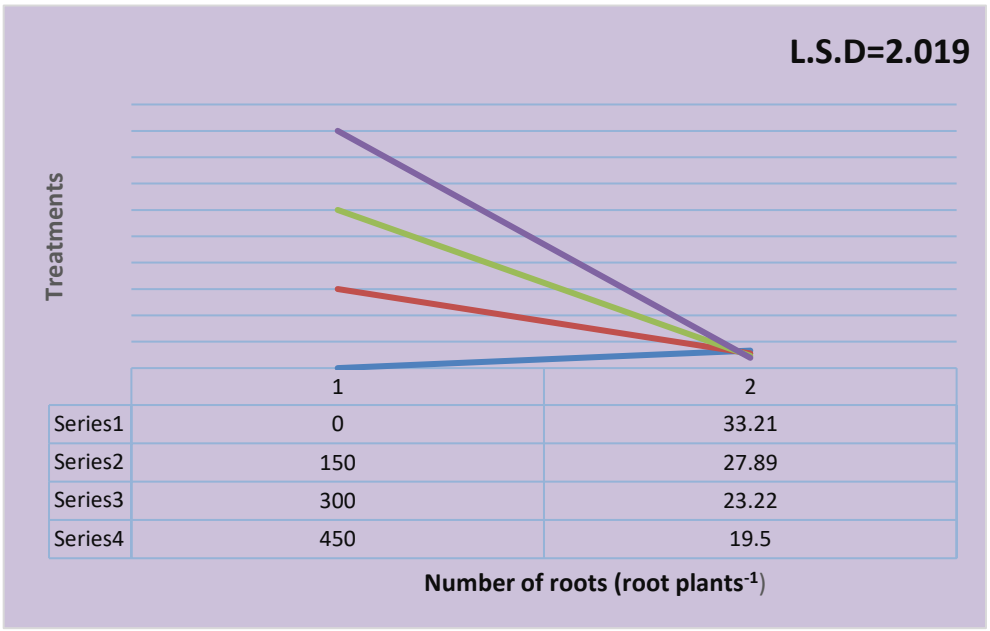
4-2: Effect of lead treatments on root growth characteristics:
4-2-1: Root length:- The results of the statistical analysis showed that the Control plants were significantly superior compared to lead-treated plants it recorded the highest average of root length (14.86 cm), while treated plants with (450 mgkg^{-1}) gave the lowest average of root length (12.31 cm) (Fig. 7).



	1	2
Series1	0	14.86
Series2	150	14.12
Series3	300	12.58
Series4	450	12.31

Figure 7 The effect of lead on the root length of Marigold (cm).

4-2-2: Number of roots:-
Obtained result showed that lead-untrated plants significant exceed in roots number trait comparing to lead-treated plants Highest average number of roots was recorded (33.21 root plant^{-1}) by control plants, while the plants treated with (450 mg kg^{-1}) recorded the lowest average number of roots, which was (19.5 root plant^{-1})(Fig.8).



	1	2
Series1	0	33.21
Series2	150	27.89
Series3	300	23.22
Series4	450	19.5

Figure 8 The effect of lead on the number of roots of Marigold (root plants^{-1})

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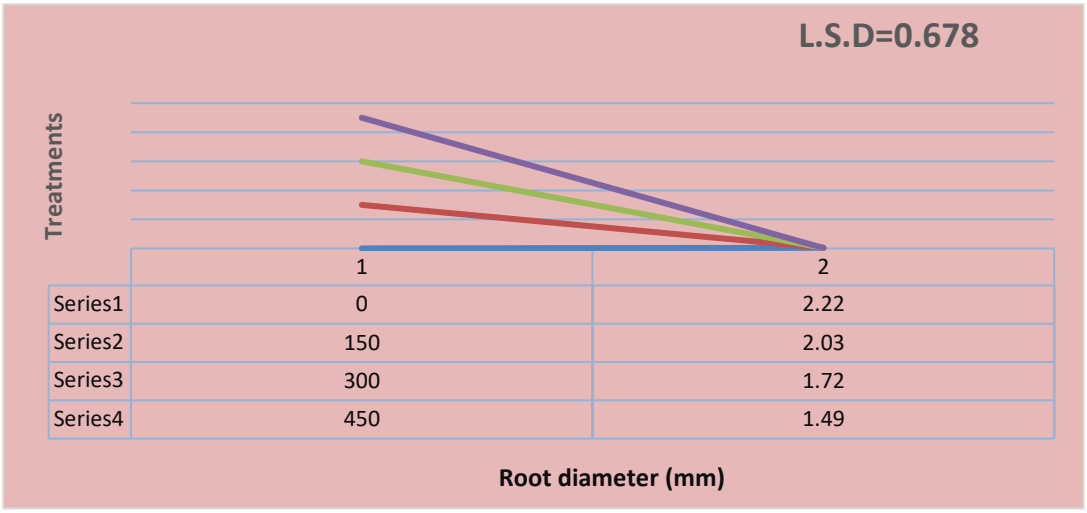
4-2-3: Root diameter :- It was noted from the results that there were no significant differences between the treatments (Control, 150, 300 mg kg^{-1}) in the average diameter of the roots, and the treatment (Control) recorded the highest average, While the treatment (450 mg kg^{-1}) gave the lowest average for this trait, which It reached (1.49 mm) (Fig. 9).



	1	2
Series1	0	2.22
Series2	150	2.03
Series3	300	1.72
Series4	450	1.49

Figure 9 The effect of lead on the root diameter of Marigold (mm)

4-2-4: Fresh weight of roots:- The result of estimated roots fresh weight indicated that there were no significant differences between lead-untreated plants and treated plants with (150 mg kg^{-1}), However, treated plants with (450 mg kg^{-1}), gave the lowest average roots fresh weight, which reached to (3.21 g) (Fig. 10)

	1	2
Series1	0	5.61
Series2	150	5.36
Series3	300	4.33
Series4	450	3.21

Figure 10 Effect of lead on the fresh weight of the roots of Marigold (g).

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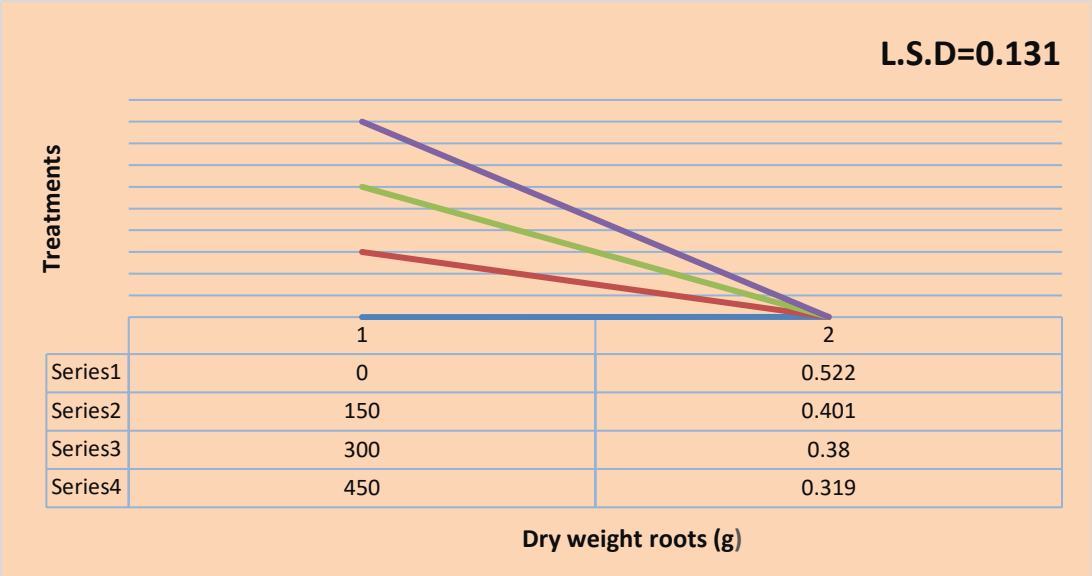
4-2-5: Dry weight of roots:

The results of the data showed that the Control treatment was significantly superior to the rest of the treatments, except for the treatment (150 mgkg^{-1}) in dry weight of roots, which recorded values of (0.522 and 0.401 gm), while the treatment (450 mg kg^{-1}) recorded the lowest values for this characteristic. It amounted to (0.319 gm). (Fig.11)



	1	2
Series1	0	0.522
Series2	150	0.401
Series3	300	0.38
Series4	450	0.319

Figure 11The effect of lead on the dry weight of the roots Marigold (g).

The results that presented in Figures (7, 8, 9, 10, 11) showed the effect of different lead concentrations on the root growth characteristics including length, number, diameter, fresh and dry weight of Marigold roots. As the results showed a significant decrease in the most of studied root growth characteristics with an increase in the Lead concentration. The treatment with lead at a concentration of (450 mg km^{-1}) was the most harmful in all roots growth characteristics compared to the control treatment. The reduction in the roots growth may be due to the stress of heavy metals that affecting in the hardness of roots cell wall, and this in turn causes a decrease in the elongation capacity of the root cells which reflected in the characteristics of The root system (Kopittke et al., 2008). In addition, lead concentrations at High levels caused increase of toxicity, which in turn causes damage to the roots and impedes their ability to absorb water and nutrients needed for the growth. Furthermore, the effect of lead on vegetative growth and what it causes in terms of small size and number of leaves, deterioration of chlorophyll pigment and weakness in the photosynthesis process, and this leads to a decrease in plant productivity, which indicates This leads to a decrease in biomass and thus a decrease in the fresh and dry weight of the root system (UNIDO, 1998 ; Shahid et al., 2015) Obtained result is consistent with a study result (Kibria et al., 2010) that showed a negatively affect of lead concentration increasing on the fresh and dry weight of roots growth of Spinacea oleracea L.

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5-Conclusion:

Based on the result of the current study, it can be concluded that the plants are negatively affected under the stress of lead pollution, as a significant decrease was observed in plant height, number of leaves, leaf area, number of branches, and the percentage of dry matter of the vegetative total, as well as a decrease in the length, number, diameter, fresh and dry weight of roots, especially with Increased lead concentrations in the soil.

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