Response of Plant Pigments and Some Growth Indicators of Date Palm Offshoots to the Combined Effect of Cadmium and Nickel

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Abstract

This study evaluated the combined effect of Cadmium at concentrations (0, 5 and 10 mg kg^{-1}) and Nickel at concentrations (0, 20 and 40 mg kg^{-1}) on plant pigments and some growth indicators of date palm sap, Al-Sayer variety. Shoot height, concentration of chlorophyll and Carotene pigments, dry weight to leaves, leaf area, trunk diameter in shoot, length and weight of roots and pollution resistance index were evaluated. The results showed significant differences in the combined effect of Cadmium and Nickel on the studied treatments. The treatment (Cadmium 10 mg kg^{-1} + Nickel 40 mg kg^{-1}) with high concentrations resulted in a significant decrease in plant pigments and indicators of vegetative and root growth compared to the treatment A, This caused a decrease in the above indicators, which amounted to (41.13 cm, 3.88mg100gm^{-1}, 1.22 mg100gm^{-1}, 5.64 g , 42.09 cm^2 , 6.21 cm , 26.82 cm , 2.13 g and 70.15%) respectively, compared with the treatment A, which gave the best results for the same studied indicators, This study contributed to the evaluation of the leaf content of plant pigments and some vegetative and root growth indicators of date palm offshoots of the Sayer c.v. growing under Cadmium and Nickel stress conditions. These were taken as significant indicators to assess the severity and intensity of heavy metal stress. So, we recommend further comprehensive studies on a larger scale on other plants and at other concentrations in order to understand the strategies that plants exhibit to reduce the damage of heavy metal stress and its effects on their cultivation and growth development.

Keywords: Date palm, Cadmium, Nickel, Chlorophyll, Carotene.

1- Introduction

Fruit of date palm One of the first plants to be cultivated, *Phoenix dactylifera L*. is native to the Arabian Peninsula and is part of the Arecaceae or Palmae family. Ajwa, Khalas, Ruthana, Sukkari, Safri, Saq'i, Khadrawi, Lulu, Hilali, and Manifi constitute some the more than 2000 different types of dates (1,2). Because they tend to bioaccumulate in addition to acting as a stressor resulting in larger economic losses, high concentrations of all essential and non-essential heavy metals in soil and water from mining operations, energy and fuel production, energy transportation, intensive agricultural practices, sludge, the dumping of industrial wastewater, and military operations have increased toxicity and growth inhibitors in a majority of plants.(3). Cadmium is an important environmental

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pollutant that is dangerous to most species, and activating many physiological responses and providing a potential danger to plants via oxidative stress, genotoxicity, obstructing of photosynthesis, and inhibition of root metabolism. (4). Nickel is a heavy metal and is an essential trace metal for humans, animals and plants, but it is toxic at high concentrations that exceed the permissible limits, which play a role in causing paleness, wilting, inhibition of growth, photosynthesis and seed germination, in addition to preventing cell division in the root layers of plants (5). In recent years, many studies have focused on the risk of heavy metals and their effects on growth indicators in date palms, including the study of (6), which showed a significant decrease in the number of leaves, leaf area, and dry weight of roots in the seedlings of cultivar growing under the influence of Cadmium stress at concentrations of (10, 30) mg kg^{-1}, while the results of the study of (7). indicated a significant decrease in the content of chlorophyll pigment in the leaves at the site close to the source of heavy metal pollution compared to the control site. This study aims to describe the growth status and effectiveness of plant pigments for date palm seedlings planted in soil contaminated with Cadmium and Nickel under the environmental conditions of Basra Governorate.

2-Material and methods

The field experiment was carried out on a private orchard. in Shatt al-Arab District / Al-Jazeera during the season 2023-2024, where 27 seedlings of two-year-old date palms of the Sayer variety were selected for their homogeneous growth and planted in pots filled with 10 kg of soil. On 6/1/2023, the seedlings were transferred to new, larger anvils with a capacity of 15 kg, and the soil was contaminated using two sources of metal stress with Cadmium chloride $CdC_{l2}.2\ 1/2\ H_2O$ at three concentrations (0, 5, 10) mg kg^{-1} and Nickel chloride $NiC_{l2}.6H_2O$ at three concentrations (0, 20, 40 mg kg^{-1}), and the seedlings were divided into 9 combination treatments A (Control), B (Nickel 20), C (Nickel 40), D (Cadmium 5), E (Cadmium 5+ Nickel 20) F (Cadmium 5 + Nickel 40) G (Cadmium 10) H (Cadmium 10 + Nickel 20) I (Cadmium 10 + Nickel 40) mg kg^{-1} All of the agricultural operations, such as irrigation, fertilization, and weeding, were carried out in the same manner, with the plants given a the compound fertilizer N-P-K (20, 20, 15) at a rate of 5 g L^{-1} in 500 ml $seedling^{-1}$.

Table (1):Some physical and chemichal Characteristics of the soil used in the experiment.

Soil characteristic	Values	**Unit**
pH	7.53	
E.C.	5.53	ds m^{-1}
OM	0.56	%
N	20	%
P	1.63	%
K	7.27	%
Sand	12.10	%
Silt	46.74	%
Clay	41.16	%
	soil texture	Silty clay

2-1 Characteristics studied:

Experimental measurements were taken at the beginning of December

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2-1-1: Shoot height: The height of each plant in The experiment was measured from the pot's soil surface to the top of the plant by a metric measuring tape, and the average was recorded for each treatment.

2-1-2: Chlorophyll and Carotene concentration in the leaves: The concentration of total chlorophyll and Carotene in the leaves was estimated based on Holden's method described by (8).

2-1-3: The dry weight of the leaves: was calculated by measuring the fresh weight of leaves taken from the experimental plants, and then draining them in an electric oven at 70°C until a steady weight was obtained, at the time the dry weight was recorded.

2-1-4: number of leaves for each plant in the experimental unit was calculated and the average was recorded..

2-1-5: Leaf area in the shoot: The leaf area was calculated using the weight method and as mentioned by (9).

2-1-6: Stem diameter: The diameter of the stem was measured for each plant in the experimental unit at a distance of 3 cm from the soil surface of the pot using a Vernier Caliper, and the average was recorded.

2-1-7: Root length: The greatest root length of each plant in the experimental unit were measured using a ruler from the meeting place of the root and stem to the root the tip, and their average was next recorded.

2-1-8: The dry weight of the roots was found after placing them in an electric oven at 70°C until the weight stabilized.

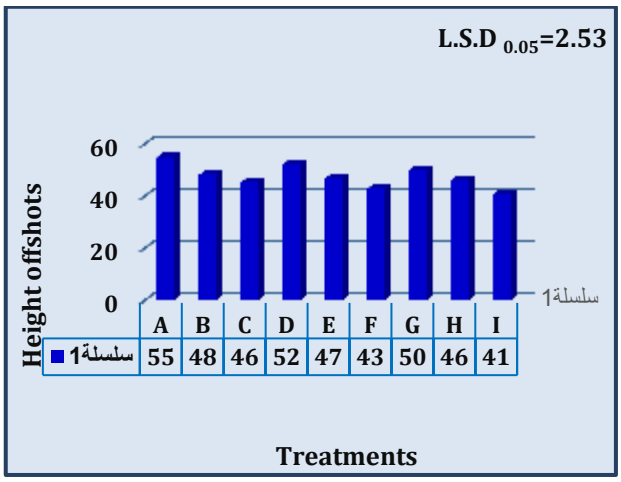
2-1-9: Pollution Resistance Index (PRI%): The percentage was calculated from the equation used by (10).

$$\text{Pollution Resistance index\%(PRI)} = \frac{\text{Average root length (cm) of contaminated plants}}{\text{Average root length (cm) of plants in the treatment A}} \times 100$$

3- Statistical design

The experiment was planned using a Randomized Complete Block Design (R.C.B.D) as a simple experiment with three blocks and 27 experimental units, with treatments dispersed at random. The results was analyzed using analysis of variance ANOVA tabel to guarantee the presence of significant differences between the studied features using the statistical program (Genstat 2013). The averages were compared using the Least Significant Difference Test (L.S.D.) at a 0.05 probability level. (11).

4-Results and discussion



Shape (1) The impact of Cadmium and Nickel on the height offshoots (cm) of Sayer date palm.

The results in Figure (1) show that treatment I led to a major decrease in the average in height offshoots and recorded the lowest average of 41.13 cm Compared to the treatment A and the rest of the treatments. The results of the statistical analysis also indicated a significant decrease in the concentration average of chlorophyll and Carotene pigments

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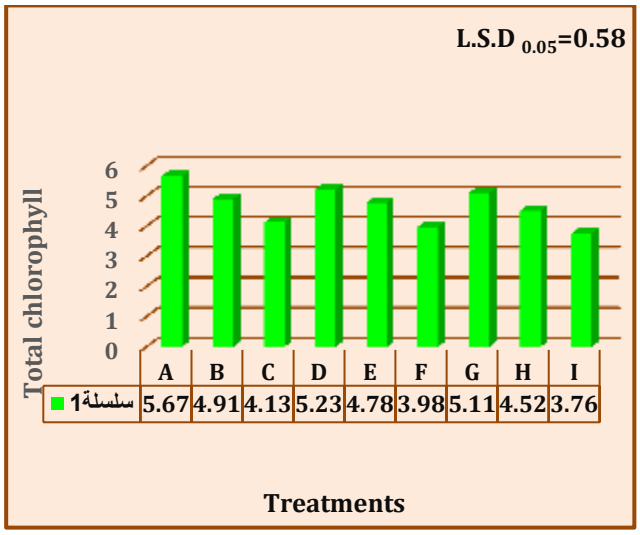
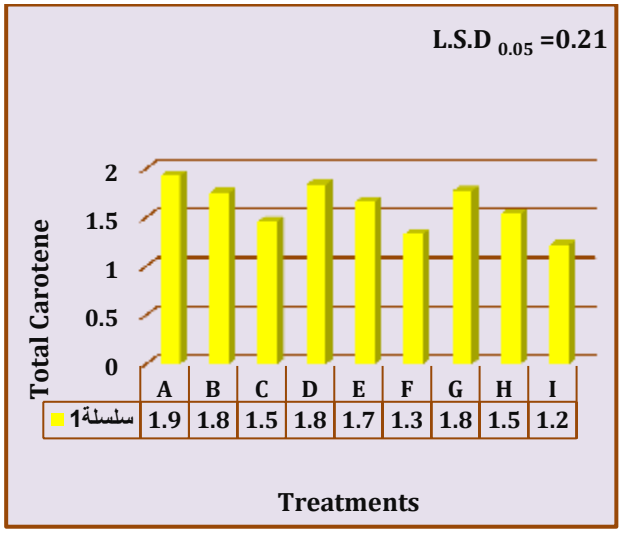
in the leaves of date palm trees under the influence of treatment I and recorded the lowest averages of 3.76 and 1.22 mg100 gm^{-1}, respectively, compared to treatment A and the rest of the treatments (Figures 2, 3).

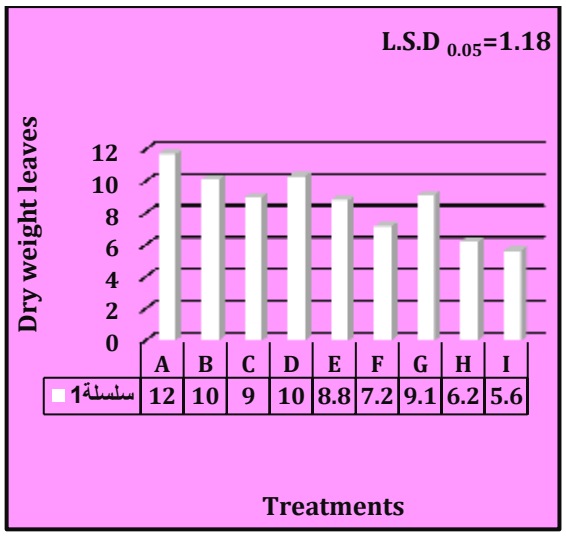


Shape (2) The impact of Cadmium and Nickel on the total Chlorophyll (mg100gm^{-1}) of Sayer date palm leaves.

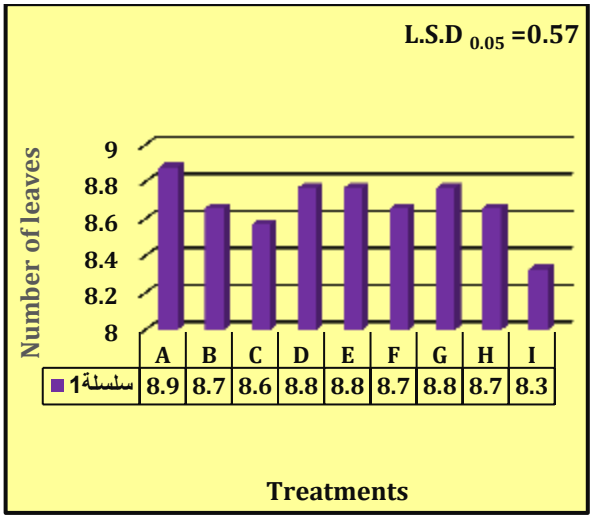


Shape (3) The impact of Cadmium and Nickel on the total Carotene (mg100gm^{-1}) of Sayer date palm leaves.

The results in Figure (4) show that exposing date palm trees to Cadmium and Nickel, especially treatments with high concentrations, led to a reduction in the dry weight rate of leaves. Treatment I which did not significantly differ from treatment H, recorded the lowest dry weight rate in leaves, reaching 5.64 g, compared to the treatment A and the rest of the treatments.



Shape (4) The impact of Cadmium and Nickel on the dry weight (gm) of Sayer date palm leaves.



Shape (5) The impact of Cadmium and Nickel on number (leaf $plant^{-1}$)of Sayer date palm leaves.

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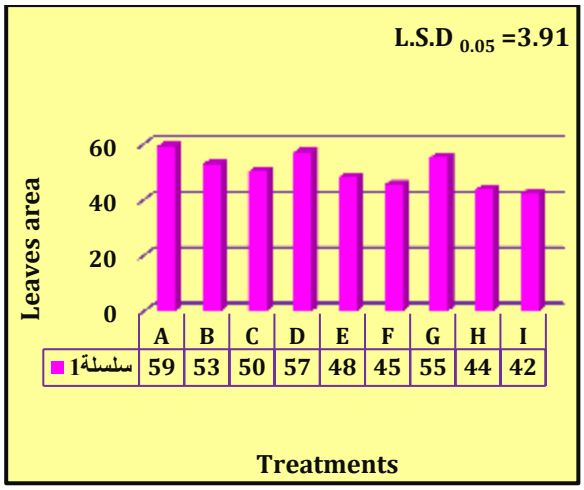
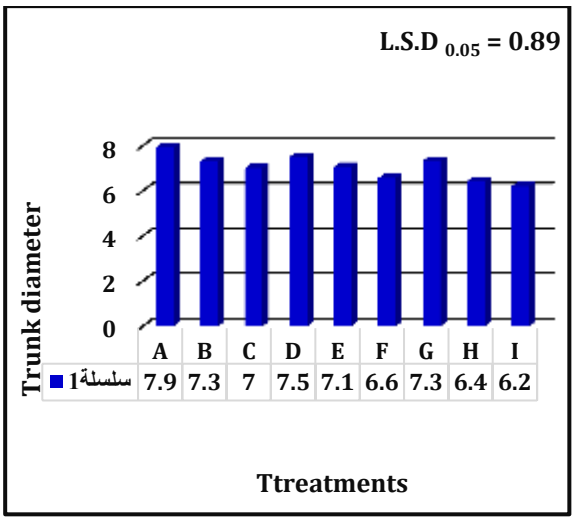
There were no significant variations in the number of leaves in date palm seedlings among treatments (Figure 5). While Figure (6) shows that treatments F,H, and I resulted in a significant decrease in the average leaf area of date palm seedlings compared to the treatment A and other treatments, treatment I was the lowest average leaf area of 42.09 cm^2, while treatment A was the highest average leaf area of 59.20 cm.

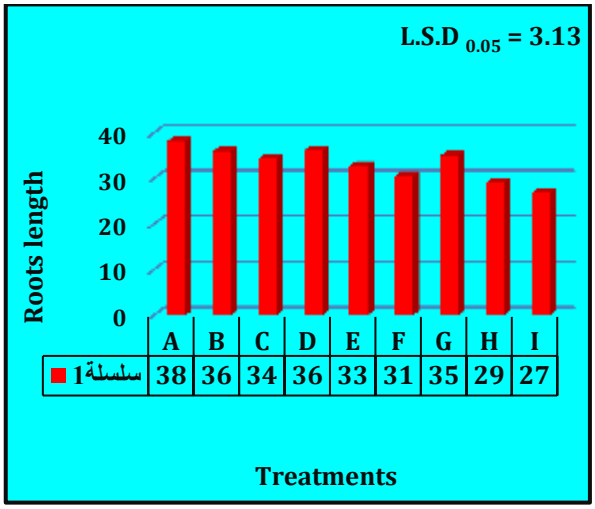


Shape (6) The impact of Cadmium and Nickel on area (cm^2) of Sayer date palm leaves.



Shape (7) The impact of Cadmium and Nickel on trunk diameter (cm) of Sayer date palm.

Figure (7) indicate that the F,H and I treatments caused a significant decrease in the diameter of the trunk of date palm offshoot, which did not show significant differences between them compared to the treatment A and the rest treatments. Treatment I got the lowest average trunk diameter (6.21 cm), as treatment A got the highest rate of trunk diameter (7.94 cm). The results of Figure (8) showed a significant decrease in the average root length in date palm seedlings under the combined effect of Cadmium and Nickel in treatments with high concentrations of H and I, which gave averages of 29.11 and 26.82 cm, respectively, compared to treatment A, which was the highest average of 38.23 cm, and with the other treatments in this trait.



Shape (8) The impact of Cadmium and Nickel on Roots length (cm) of Sayer date palm.

The statistical analysis also showed that treatment I caused a decrease in the average of dry weight in the roots, which did not differ significantly from treatments F, and H in this trait, and recorded the lowest rate of weight, which amounted to 2.13g,compared to the treatment A and the rest of the treatments in this trait (Figure 9).

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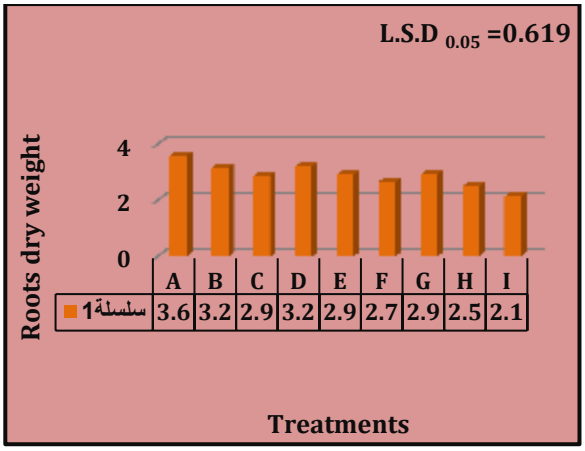
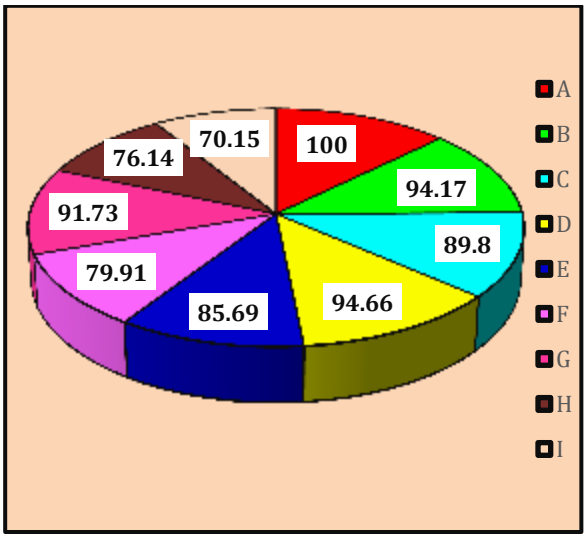


Shape (9) The impact of Cadmium and Nickel on Roots dry weight (gm) of Sayer date palm.

Figure (10) shows the percentage of the pollution resistance index that was adopted as a real standard for evaluating the tolerance of date palm seedlings to heavy metal toxicity, as the results obtained indicate a significant difference in this percentage, as the treatment A gave uncontaminated plants a percentage of 100%, then this percentage began to decrease in the treatments of the single and combined effect, and the lowest percentage of this indicator was in treatment I, amounting to 70.15%.



Shape (10) The percent of pollution resistance index (PRI %)

The results of the data shown in Figures (1-7) show the effect of treatments on plant pigments and some vegetative growth indicators of date palm seedlings, i.e. seedling height, chlorophyll and Carotene pigments, dry weight in leaves, number of leaves, leaf area, and trunk diameter showed a decreasing in the studied traits, except for the number of leaves, with increasing concentrations of Cadmium and Nickel. The lowest rates were recorded in treatment I (Cadmium 10 mg Kg^{-1} + Nickel 40 mg Kg^{-1}) and it was the most harmful in all traits compared to the treatment A. This may be attributed to the increased toxicity of heavy metals as a result of their accumulation in plant tissues, thus inhibiting many vital processes such as photosynthesis, inhibiting some enzyme systems, preventing the formation of proteins, chlorophyll, cell division, and inhibiting the respiration process through disturbances in electron transport (12). (13). Also suggested: Heavy metal toxicity arises due to the excessive generation of reactive oxygen species (ROS) and methyl glyoxal (MG), which result in the breakdown of lipids of cellular membranes, protein oxidation, and enzyme inhibition., DNA damage and/or interact with other important components of cells. (14), found that organic lead disrupts the spindle fiber mechanism in the process of cell division in plants, while (15). discovered a decrease in the activity of the Glutathione reeducates enzyme under the influence of Cadmium and Nickel stress in Alyssum argentum. The results of this study are consistent with the results of many studies conducted on various plants. (16) It showed the combined effect of lead, chromium, and nickel to a reduction in all vegetative growth traits in Caesarian glauca, Tax odium distichum and Populous nigra trees with increasing their concentrations.(17). also showed that with increasing concentration of Nickel and lead in

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the soil, there was a decrease in the length of Dahlia plant compared to the treatment A.

The results of the data in Figures (8, 9) show the effect of treatments on root length and dry weight, The results showed a significant decrease in the studied has with increasing amounts of Cadmium and Nickel, and the lowest rates were recorded in Treatment I (Cadmium 10 mg Kg^{-1} + Nickel 40 mg Kg^{-1} and it was the most harmful in these traits compared to the treatment A and the rest of the treatments. This may be attributed to the increased toxicity of heavy metals as a result of their accumulation in the tissues of plant roots, which in turn leads to damage to the roots and thus disturbance in water absorption and regulation of plant nutrition conditions by the roots (18). It is consistent with what (19). found in their study, which showed that Cadmium has significant inhibitory effects on the elongation of the roots of Abelmoschus Mani hot, Salvia splendens and Tagetes erecta plants. As for Figure (10), it indicated a large variation in the percentage of the pollution resistance index, as The values of this index indicated the level of variation in the damage to the plants of the contaminated treatments compared to the plants of the treatment A. (20). noted that the indicators of pollution resistance (tolerance) in Chlorophytum comosum plants were all higher than 100%, which indicates the efficiency of bioremediation of soil contaminated with Cadmium at a concentration of 200 mg kg^{-1}. On the other hand, it was observed that the shoots remained alive at a rate of 100%, which indicates that the shoots of date palm trees can tolerate the toxicity of contaminated treatments with high concentrations under Cadmium and Nickel stress, which can be explained by the fact that palm trees produce Metallothioneins proteins, and then these proteins form a complex that binds to heavy metals and then transports them to the vacuoles in the cells and reduces their severity (21).

Conclusions

At this study, The results showed that the combined effect of Cadmium and Nickel had a significant negative impact on the studied growth traits of date palm seedlings, especially in the treatment with high concentrations. (Cadmium 10 mg kg^{-1} + Nickel 40 mg kg^{-1}), which led to a significant reduction in the seedling height rate, chlorophyll pigment, Carotene pigment, dry weight in leaves, leaf area, trunk diameter, root length and dry weight, and the percentage of pollution resistance index, while the treatment A showed higher rates of these traits. These results highlight the sensitivity of date palm leaves and roots to heavy metal stress, which urges efforts to develop the efficiency and ability of date palm trees to confront abiotic stresses in order to mitigate their effects.

References

1-Souli, I.; Jemni, M.; Rodríguez-Verástegui, L.L.; Chaira, N.; Artés, F.; Ferchichi, A. (2018). Phenolic composition profiling of Tunisian 10 varieties of common dates (*Phoenix dactylifera* L.) at tamar stage using LC-ESI-MS and antioxidant activity. J. Food Biochem., 42,1.

2-Hussain, M.I.; Farooq, M.; Syed, Q.A.(2020). Nutritional and biological characteristics of the date palm fruit (*Phoenix dactylifera* L.) -A review. Food Biosci., 34. https:// doi:10.1016/j.fbio.2019.100509

3-Slater, A.; Scott, N.W. and Fowler, M.R. (2006). Plant biotechnology the genetic manipulation of plants, 2nd edn. Oxford University Press, New York.

4-Andresen, E., Kupper, H. (2013). Cadmium Toxicity in Plants. In: Sigel, A., Sigel, H., Sigel, R. (eds) Cadmium: From Toxicity to Essentiality. Metal Ions in Life Sciences, vol 11. Springer, Dordrecht.

ISSN 2072-3857

5-Bhalerao, S.A.; Sharma ,A.S. and Poojari, A.C.(2015).Toxicity of Nickel in Plants. International Journal of Pure and Applied Bio Science, *Int. J. Pure App. Biosci.,* 3 (2): 345-355.

6-Zouari, M.; Ben Ahmed, C.; Zorrig, W.; Elloumi, N.; Rabhi, M.; Delmail, D.; Ben Rouina, B.; Labrousse, P. and Ben Abdallah, F. (2016). Exogenous proline mediates alleviation of Cadmium stress by promoting photosynthetic activity, water status and antioxidative enzymes activities of young date palm Phoenix dactylifera L. Ecotoxicol. Environ. Saf., 128:100 -108

7-Gabash,H.M., Attaha,A.H.M. and Sabti,M.Z.(2020). Studying the pollution with heavy elements resulting from fuel combustion from oil wells in the pigment of total chlorophyll and some chemical traits of date palm leaves (*Phoenix dactylifera* L.) Hilawi cultivar growing in Basra province,IRAQ, Plant Archives 20 (2): 5151-5157.

8-Howrtiz , W. (1975). Official Methods of Analysis. Association of Official Analyticl Chemists , Washington , D.C. , U.S.A .

9-Morsi, Mustafa Ali and Hussein Ali Tawfiq and Abdel Azim Abdel Gawad. (1986). Fundamentals of Agricultural Research. Anglo-Egyptian Library - Cairo. Arab Republic of Egypt.

10-Wilkins, D.A.(1957). A technique for the measurement of lead tolerance in plants. Nature, 180: 73-78.

11-Bashir, Saad Zaghloul.(2003).Your Guide to the Statistical Program SPSS. Tenth Edition. Arab Institute for Training and Statistical Research. - 159.170

12-Adress, M., S. Ali, M. Rizwan, M.Z. Rehman, M. Ibrahim, F. Abbas, M. Farid, M.K. Qayyum and Irshad,M.K.(2015). Mechanisms of silicon-mediated alleviation of heavy metal toxicity in plants: a review. Ecotoxical. Environ. Saf., 119: 186-197.

13-Hossain, M.A., Piyatida, P. Teixeira da Silva, J.A. and Fujita, M.(2012). Molecular mechanism of heavy metal toxicity and tolerance in plants: central role of glutathion in detoxification of reactive oxygen species and methylglyoxal and in heavy metal chelation. J. Botany, pp: 1-37.

14-Foy, C.D., R.L. Chaney and White, M.C. (1978). The physiology of metal toxicity in plants. Ann. Rev. Plant Physiol., 29: 511-566.

15-Schickler, H. and Capsi, H.(1999). Response of antioxidative enzymes to Nickel and Cadmium stress in hyperaccumulator plants of the genus Alyssum. Physiologia Plantarum, 105(1): 39-44.

16-Abbaas, M.M.(2002). Effect of some heavy metals in the irrigation water on growth and chemical constituents of some timber trees. Ph. D. Thesis, Fac. Agric., Cairo Univ.

17-Shivhare,L.and Sharma,S.(2012). Effect of toxic heavy metal contaminated soil on an ornamental plant Georgina Wild (Dahlia). Inter. J. Current Res. and Rev., 4(19): 25- 35.

18-Azza, A.M. Mazher (2006). Response of Leuceana leucocephala seedlings grown under lead pollution to phosphorin Application in sandy soil. World Journal of Agricultural Sciences 2(2): 217-222.

19-Wang, X. and Zhou, Q.(2005). Ecotoxicological effects of Cadmium on three ornamental plants. Chemosphere, 60(1): 16-21.

hyper accumulator. Environmental Monitoring and Assessment., 184 (2): 929-937.

20-Wang, Y., A. Yan and Dai, J. (2012). Accumulation and tolerance characteristics of Cd in *Chlorophytumcomosum*: a popular ornamental plant and potential Cd

21-Zagorchev L.S., Kranner C.E. and Odjakova I. (2013). A central role for thiols in plant

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tolerance to abiotic stress. Int. J. Molecular Sci. .
14:7405-7432.

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