Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 1 Vol 8 No 1 2023

Article

Lead and cadmium in wheat plants as influenced by water quality, water stress and potassium.

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Available from: http://dx.doi.org/10.21931/RB/CSS/2023.08.01.100

Abstract: The study was conducted using plastic pots during the growing season 2020-2021 in private field crops at the Holy Karbala Governorate to study the effect of the quality of water, soil moisture and potassium levels on lead and cadmium of wheat plant var. A.L. baraka. A factorial experiment was carried out using a completely randomized design (C.R.D.) with three replications, which included two types of irrigation water treated heavy water and soft water, three levels of field capacity, i.e., %, 50% and 100% and four levels of potassium, i.e., 0, 1000, 2000 and 3000 mg. L^{-1} The experiment included 72 experimental units. The results were statistically analyzed, and the means of treatments were compared using the least significant difference under the probability level of 0.05. The following characteristics were measurements: The element lead and cadmium in the roots, leaves and leaves were obtained; results were statistically different in the traits under study; treated water treatment gave the highest values for the concentration of lead and cadmium in leaves and grains, their averages were 17.38 mg^{-1} 0.691 mg mg^{-1}, 0.207 mg. .061 mg.kg-1 and 0.031 mg.kg-1 and 6.48, respectively. The highest concentration is 6.69 mg. Direct lead to water (treated) was 3.983 over its counterpart in plain water 1.035, with an increase of 298.3%. The heavy water treatment gave a very high value with leaves cadmium concentration of 0.6916 mg. Cadmium 1 mg.kg.compared to the treatment of soft water, which gave the value 0.0311 $mg.kg^{-1}$, with an increase of 565.59%.Treatment of 100% of the field capacity value gave the highest lead and cadmium concentration values in roots, leaves and grains 14.41 mg^{-1},2.716,1.389,0.480,0.383 and 0.181 sequentially. The addition of (3000) potassium decreased the lead concentration in the roots, leaves and grains due to potassium application of 9.73 mg^{-1},2.170,1.056,0.39,0.233 and 0.079 sequentially.

Keywords: lead, cadmium, wheat plant, water quality, water stress, potassium.

Introduction

Bread wheat (Triticumaestivum L.) is the first cereal crop in the world in terms of its importance, cultivated area and global production, being a primary food for more than a third of the world's population[1]. Water sources are the most important natural resources on which the agricultural development of any country in the world depends. As a result of the significant expansion in the agricultural field to address the worsening food crisis in the world, water availability has become the primary determinant of agricultural production, especially in arid and semi-arid areas due to the prevailing harsh climatic conditions[2]. Water stress is one of the most critical obstacles to the growth and productivity of the wheat plant, as it contributes to shortening the plant height, reducing the leaf area and the growth of leaves, which hurts growth processes, cell division and elongation, which is reflected on the productivity of wheat and reducing the yield of the unit area compared to developed countries. Water prevents the crop from exploiting its inherent physiological and genetic potential to the highest level[3]. Therefore, thinking about developing strategies has become necessary to confront this problem by rationalizing water consumption in quantity and quality and finding possible solutions to balance water resources and raise the efficiency of water use—industrial, agricultural and health drainage. Using wastewater in irrigation is one of the modern strategies that reduce the use of fresh water in irrigation, which reduces water scarcity problems. Although this water contains nutrients such as nitrogen and phosphorous and micronutrients that benefit the crops that are irrigated with this water, it contains heavy elements that may accumulate in the soil and plants as a result of its use in irrigation with concentrations that are harmful to the plant and the living organisms that feed on it[4]. The use of wastewater in treatment is part of the national water mobilization and exploitation strategy, as it contributes to the protection of the natural environment, the sustainability of agricultural production, the economy of traditional water and the expansion of irrigated areas. It also contributes to reducing the intrusion of saline water into coastal groundwater by using the artificial feeding of water resources with treated waste water[5,6]. Heavy metals cause significant health risks to humans and animals. These elements may accumulate in crops in different concentrations and in different parts. Some of these elements are concentrated in the roots, some in the leaves, and a few in the fruits. This element or sludge is used as fertilizer for the soil because some crops absorb it quickly, unlike other elements such as lead and mercury. The plant does not readily absorb or move to the edible part of the plant[7]. In addition to the use of fertilizers and irrigation techniques and the factors involved in production, such as the use of potassium fertilizers, which did not receive much care and use in Iraqi soils, as did nitrogen and phosphate fertilizers, because of the prevailing belief that there is sufficient storage of potassium in these soils that can meet the requirements of the plant's need because of its importance in resisting pathogens and resisting sluggishness. Through its role in the process of lignin and thickening of cell walls and its active role in the various metabolic activities of the plant, especially under drought conditions, high temperatures and fluctuations in the amount of rain falling, its importance lies in increasing the tolerance of water stress through increasing the osmotic pressure of cells, and increasing the relative water content In the tissues of the leaves and controlling the movement of closing and opening of the stomata[8] Therefore, the study aimed:

We are assessing the effect of water stress on the concentration of Pb and Cd.

Studying the best concentration level of potassium helps increase growth conditions and reduce the negative impact of heavy elements.

Studying the effect of the interaction between different levels of water stress, added potassium and water quality on these two elements.

The possibility of using treated heavy water to irrigate plants.

Materials and Methods

A factorial experiment was carried out in plastic pots with a diameter of 30 cm and a capacity of 10 kg of soil in a private field for the growing season of 2020-2021. The wheat crop Triticum aestivum L. cultivar (Al baraka) seeds were used. A factorial experiment was conducted using a completely randomized design (C.R.D.) with three replications. The experiment included studying the effect of the following factors: The first factor is water quality (treated heavy water and soft water); the second factor is water stress (25%, 50% and 100%) of the value of the field capacity, The third factor is the addition of potassium by spraying from a source of potassium sulfate (0,1000,2000and3000) mg. L-1 is represented hereafter by the K letter. Accordingly, the number of experimental units becomes 72 (2 x 3 x 4 x 3) for water quality, field capacity, potassium and replicates. The heavy water plant in Karbala was selected for the study, and polyethylene bottles with a volume[5] of liters were used to collect samples after they were washed with hydrochloric acid (10%) to get rid of organic matter and impurities. They were washed with sample water before taking it. The concentration of heavy elements was estimated when the water samples were transferred to the laboratory, where (1 liter) of water was filtered through a filter paper with a diameter of 0.45 microns in diameter, Sartorius type, after it was cleaned with dilute (0.05) N nitric acid and deionized distilled water and dried at (80 °C). m) in the oven[9] and then added to the filtered water (5 cm3) of concentrated nitric acid. Lead and cadmium were measured using a Flame Absorption Spectrophotometer Model 210 V6.p

Determination of cadmium and lead in roots, leaves and grains:

Digest the plant samples of plant materials according to Method[10] by taking 0.2 g of dry, ground substance into 100 ml glass digestion tubes and following the Di-acid method by adding 5 ml of concentrated sulfuric acid H2SO4 to the digestion tube with the addition of 2 ml. of perchloric acid HClO4 to increase the efficiency of the oxidation process. Then, the tubes were placed in a sand bath equipped with a heat source until the color of the solution became clear, then cooled, and the volume was completed to 100 ml with distilled water and filtered to be ready for determination. The samples were placed in the Flame Atomic Absorption Spectrophotometer to take the reading. Other materials and methods are fully described in [11].

Results and Discussion

Root concentration of lead:

Table 1 shows the effect of water quality, field capacity, potassium concentration and their interactions on lead concentration in wheat roots. Soft water gave the lowest concentration of this element, amounting to 6.693 mg.kg-1, while the highest concentration was 17.380 mg.kg-1 due to heavy water, with an increase of 159.7%. Field capacity treatments statistically affected this trait, as 25% treatment gave the lowest concentration, 9.956 mg.kg-1, while the highest value obtained from 100% field capacity was 14.419 mg.kg-1, with an increased percent of 44.8%. Potassium significantly affected this trait, as the concentration decreased by increasing potassium levels, and the highest value of 14.719 $mg.kg^{-1}$ resulted from the control treatment. In comparison, the lowest value was 9.734 $mg.kg^{-1}$ resulting from the treatment of 3000 $mg.l^{-1}$, and the decrease percentage was 51.2%. The two interactions significantly affected this trait, as the treatment of soft water with a capacity of 25% gave the lowest value of 5.650 $mg.kg^{-1}$. In contrast, the highest value, 21.136 $mg.kg^{-1}$, was obtained from the heavy water treatment with a field capacity of 100%. The interaction treatment between water quality and potassium statistically affected this trait, as the treatment of soft water with the addition of the highest potassium concentration gave the lowest value of 5.810 $mg.kg^{-1}$; on the other hand, the treatment of heavy water without the addition of potassium gave the highest value 21,843 $mg.kg^{-1}$. Field capacity and potassium concentration statistically affected lead concentration, as 50% field capacity and 3000 $mg.L^{-1}$ treatment gave the lowest value of 8.627 $mg.kg-^{1}$. In comparison, 100% field capacity treatment without potassium added gave the highest value of 16,971 mg.kg^{-1}.The triple interaction showed a significant effect on this trait, as the triple interaction treatment gave normal water with a field capacity of 25% with the addition of potassium at a concentration of 3000 mg.L^{-1}, the lowest value of 4.886 mg.kg^{-1}. In comparison, the highest value was obtained from the heavy water treatment with a field capacity of 100%. Without adding potassium, it reached 25,582 mg.kg^{-1}.

water quality I	Field capacity S%	K(mg^{-1})				I× S
		0	1000	2000	3000	
Soft water	25	6.917	5.565	5.232	4.886	5.650
	50	7.506	7.118	6.249	6.036	6.727
	100	8.360	8.009	7.933	6.508	7.702
heavy water	25	17.648	13.433	13.337	12.628	14.261
	50	22.301	18.754	14.695	11.218	16.742
	100	25.582	23.282	18.552	17.129	21.136
Mean K		14.719	12.693	11.000	9.734	0.538
L.S.D. (0.05)		K = 0.439				
		K × I× S= 1.077				
I		K(mg^{-1})				Mean I
		0	1000	2000	3000	
Soft water		7.594	6.471	6.471	5.810	6.693
heavy water		21.843	18.489	15.528	13.658	17.380
L.S.D. (0.05)		0.622				0.311
S		K(mg^{-1})				Mean S
		0	1000	2000	3000	
25		12.282	9.499	9.282	8.757	9.956
50		14.903	12.936	10.472	8.627	11.735
100		16.971	15.645	13.243	11.819	14.419
L.S.D. (0.05)		0.762				0.381

Table 1. Effect of water quality, field capacity, potassium concentration and their interactions on lead concentration (mg.kg^{-1}) in the roots of the wheat plant.

Lead concentration in leaves:

Table 2 shows the effect of the study factors and their interactions on the concentration of lead in the papers. The quality of the water affected the concentration of lead in the leaves, as the treatment of heavy (treated) water (3.983) exceeded its counterpart in ordinary water (1.035), with an increase of potassium treatments had a significant effect on this trait; as the concentrations of lead decreased with an increase in potassium concentrations. Comparison treatment gave the highest concentration of lead (2.953), while the lowest lead concentration was obtained from the highest potassium concentration of 3000 mg L^{-1} giving (2.170 mg.kg^{-1}), with a percentage decrease of 2.170. 26.5%, respectively .The effect of the binary interaction between soft water and capacity was significant in this trait, as heavy water treatment and a capacity of 100%

gave the highest values (4.315). In comparison, the lowest value was accompanied by regular water treatment and a capacity of 25%, as it gave 0.946 with an increased percent of 356.1%, and the rest of the values came in between these two values.

The interaction between the quality of water and potassium was shown, as the treatment of heavy water without adding potassium gave the highest value, amounting to 4.708, while the lowest values were recorded by the treatment of normal water, and the highest potassium concentration reached 0.906, with an increase of 419.6%, and the rest of the treatments recorded median values between these two values. It should be noted that there was no significant effect on this trait with the effect of the two-way interaction between the field capacity and potassium, and the three-way interaction also had no effect between the studied factors.

Water quality I	Field capacity S%	K(mg-1)				I× S
		0	1000	2000	3000	
Soft water	25	1.137	0.948	0.901	0.798	0.946
	50	1.196	1.065	1.000	0.907	1.042
	100	1.265	1.111	1.080	1.013	1.117
heavy water	25	4.328	3.561	3.358	3.110	3.589
	50	4.881	3.99	3.878	3.428	4.044
	100	4.914	4.322	4.257	3.766	4.315
Mean K		2.953	2.499	2.412	2.170	0.134
L.S.D. (0.05)		K= 0.109				
		K × I× S=N.S				
I		K(mg-1)				Mean I
		0	1000	2000	3000	
Soft water		1.199	1.041	0.994	0.906	1.035
Heavy water		4.708	3.958	3.831	3.435	3.983
L.S.D. (0.05)		0.155				0.077
S		K(mg-1)				S
		0	1000	2000	3000	
25		2.733	2.254	2.13	1.954	2.268
50		3.038	2.528	2.439	2.167	2.543
100		3.089	2.717	2.668	2.390	2.716
L.S.D. (0.05)		N.S.				0.095

Table 2. Effect of water quality, field capacity, potassium concentration and their interactions on lead concentration (mg. kg^{-1}) in leaves of wheat plant.

Lead concentration in grains:

It is evident from the results of Table 3 that the lead content in the grain increased due to the treatment of heavy water (treated) than it was in soft water. Heavy water treatment gave (1.9914) compared to the treatment of soft water, which gave (0.5175), with an increase of 284.8%, significantly affecting the field capacity. In the content of lead in the leaves, the content decreased with the increase of the field capacity, and it was 1.3893, 1.2266 and 1.1474 for capacities 25, 50 and 100%, respectively, and the percentage decrease was 11.7 and 17.4, respectively.

Water quality I	Field capacity S(%)	K(mg-1)				I× S
		0	1000	2000	3000	
Soft water	25	0.540	0.507	0.453	0.400	0.475
	50	0.555	0.535	0.500	0.451	0.510
	100	0.632	0.598	0.568	0.474	0.568
Heavy water	25	2.128	1.883	1.714	1.555	1.820
	50	2.161	1.995	1.939	1.679	1.944
	100	2.457	2.441	2.164	1.780	2.210
Mean K		1.412	1.326	1.223	1.056	0.067
L.S.D. (0.05)		K = 0.055				
		K × I× S= N.S				
I		K(mg-1)				Mean I
		0	1000	2000	3000	
Soft water		0.576	0.546	0.507	0.441	0.517
Heavy water		2.249	2.106	1.939	1.672	1.991
L.S.D. (0.05)		0.078				0.039
S		K(mg-1)				Mean S
		0	1000	2000	3000	
25		1.334	1.195	1.084	0.977	1.147
50		1.358	1.264	1.220	1.065	1.227
100		1.544	1.519	1.366	1.127	1.389
L.S.D. (0.05)		N.S.				0.047

Table 3. Effect of water quality, field capacity, potassium concentration and their interactions on lead concentration (mg. kg^{-1}) in wheat grains.

The amount of lead in grains decreased with increased potassium, as the control treatment gave the highest value (1.3214), while the lowest value was obtained from the treatment of 3000 mg L^{-1} potassium. The percentage decreases were 2.8, 6.8 and 11.6 %, respectively. All the binary interactions significantly affected this trait, as the treatment of heavy water (treated) with a capacity of 25% gave the highest values (2.2104). In comparison, the treatment of soft water and a capacity of 100% gave the lowest values (0.4747) with a decrease of 79%, and the rest of the values were intermediate between these two values.

The effect of the interaction between water quality and potassium, as the treatment of heavy water (treated) without adding potassium, gave the highest value (2.0958). The lowest value for this trait came from the interaction between regular water and the highest potassium concentration of 3000 mg L^{-1} (0.4936), with a decrease of 76.4%, and the rest of the values came in between these two values. Also, the effect of the interaction between field capacity and potassium, as the treatment of 25% of field capacity and concentration of 2000 mg L^{-1}, gave the highest values (1.5447) and the lowest value obtained from 100% field capacity and 1000 mg L^{-1} potassium (0.9770) and a decrease percent of 36.8% and the rest of the values were intermediate between these two. The effect of the triple interaction between the studied factors on this characteristic was associated with the highest value of heavy water treatment with a field capacity of 25% and 2000 mg L^{-1} (2.4570), while the lowest value (0.3988) resulted from the treatment of soft water with a capacity of 100% and a concentration of 2000 mg L-1 Potassium, with a decrease of83.8%, and the rest of the treatments were intermediate between these two treatments.

Cadmium concentration in the roots:

Table (4) shows the effect of the study factors and their interactions on the cadmium concentration in the roots of the wheat plant. The water quality had a noticeable effect on the cadmium concentration in the roots of the plant, as the heavy water treatment outperformed the soft water treatment, where the values were 0.200 and 0.675 mg. kg^{-1} for soft water and heavy, respectively, with a increase of 237.5%. Field capacity treatment significantly affected this trait, as the values decreased with increasing field capacity, which were 0.382, 0.450 and 0.480 mg.kg-1 for capacities 25, 50 and 100% field capacity, respectively, and the percentage increases were 25.7 and 6.7%, respectively. Cadmium values decreased with increasing levels of potassium, where the control treatment gave 0.480 mg.kg^{-1}. In comparison, the treatment gave the highest potassium concentration of 0.396 mg.kg^{-1}, with a decrease of 17.5%, and the values of the other two treatments were intermediate between these two values. Interactions significantly affected this trait. The interaction between water quality and field capacity gave significant differences, as the heavy water treatment with a field capacity of 100% gave the highest value (0.739) mg.kg^{-1}.

In comparison, the lowest value resulted from soft water treatment with a field capacity of 25%, which gave 0.173 mg.kg^{-1} with an increase of 327.2%. The rest of the values of the treatments came as a median between these two values. The effect of the interaction between water quality and potassium in this trait, as the treatment of soft water gave the lowest values, amounted to 0.170 mg. kg^{-1}, while the treatment of heavy water without adding potassium, gave the highest values, which amounted to 0.735 mg. kg^{-1} with an increase of 332.4%, it should be noted that in both types of water, potassium reduced the cadmium concentration. The value in soft water decreased from 0.225 to 0.170 mg.kg^{-1} and from 0.735 to 0.62.2 mg.kg^{-1} in heavy water. The interaction between field capacity and potassium had a significant effect on this trait, as the 25% treatment field capacity and the highest concentration of potassium gave the lowest values of 0.311 mg.kg^{-1}, while the 100% treatment field capacity without adding potassium gave the highest values amounted to 0.503 mg.kg^{-1} with a percentage increase of 61.7%. The effect of the tri-interaction between the factors under study was significant in this trait, as the treatment of soft water with a field capacity of 25% and the highest concentration of potassium gave the lowest value(0.123) mg.kg^{-1}, while the highest value (0.760) resulted from the treatment of heavy water with a field capacity of 100% without potassium addition. The rest of the tri-interaction values came in between these two values.

Water quality I	**Field capacity S (%)**	**K(mg-1)**				**I× S**
		0	**1000**	**2000**	**3000**	
Soft wa-	**25**	**0.197**	**0.189**	**0.182**	**0.123**	**0.173**

ter	50	0.232	0.207	0.196	0.187	0.206
	100	0.245	0.224	0.213	0.200	0.221
Heavy water	25	0.713	0.629	0.522	0.498	0.591
	50	0.730	0.698	0.682	0.666	0.694
	100	0.760	0.752	0.744	0.701	0.739
Mean K		0.480	0.450	0.423	0.396	0.007
L.S.D. (0.05)		K = 0.006				
		K × I× S= 0.014				
I		K(mg-1)				Mean I
		0	1000	2000	3000	
Soft water		0.225	0.207	0.197	0.170	0.200
Heavy water		0.735	0.693	0.649	0.622	0.675
L.S.D. (0.05)		0.008				0.004
S		K(mg-1)				Mean S
		0	1000	2000	3000	
25		0.455	0.409	0.352	0.311	0.382
50		0.481	0.453	0.439	0.427	0.450
100		0.503	0.488	0.471	0.451	0.480
L.S.D. (0.05)		0.010				0.005

Table 4. Effect of water quality, field capacity, potassium concentration and their interactions on cadmium concentration (mg. kg-1) in the roots of wheat plant.

Cadmium concentration in leaves:

Table 5 shows that water quality, field capacity, potassium and all their interactions significantly affected the concentration of cadmium in wheat leaves. The heavy water treatment gave a very high value (0.5118) mg.kg-1 compared to the treatment of soft water (0.0617) mg.kg-1. The field capacity also statistically significantly affected this trait, as the cadmium concentrations increased with increased field capacity. 25% field capacity treatment gave the lowest concentration (0.2019)mg.kg-1, while the highest concentration of cadmium was associated with a 100% treatment, a field capacity (0.3571) mg.kg-1 with an increase of 76.8%. The concentration of cadmium decreased with an increase in potassium concentration, as the control treatment gave 0.3363 mg.kg-1 decreased to 0.2333 mg -1 kg, with the addition of 3000 mg. liter $^{-1}$ potassium, and the decrease was 30.6%. The binary interactions significantly affected this trait. Soft water treatment with a field capacity of 25% gave the lowest values (0.0437) mg.kg^{-1}, while the heavy water treatment with a field capacity of 100% gave the highest values (0.6300) mg.kg^{-1}. The interaction between water quality and potassium also affected this trait, as soft water treatment and the highest potassium concentration gave the lowest value(0.0482) mg.kg^{-1}. In contrast, the highest value was associated with the heavy water treatment without adding potassium (0.5970)mg.kg^{-1}.

Water quality I	Field capacity S (%)	K(mg-1)				I× S
		0	1000	2000	3000	
Soft water	25	0.0589	0.0438	0.0377	0.0343	0.0437
	50	0.0741	0.0655	0.0469	0.0425	0.0573
	100	0.0937	0.0888	0.0862	0.0678	0.0841
Heavy water	25	0.5290	0.3956	0.2619	0.2541	0.3602
	50	0.5882	0.5769	0.5674	0.4485	0.5453
	100	0.6739	0.660	0.6336	0.5523	0.6300
Mean K		0.3363	0.3051	0.2723	0.2333	0.0141
L.S.D. (0.05)		K= 0.0086				
		K × I× S= 0.0210				
I		K(mg-1)				Mean I
		0	1000	2000	3000	
Soft water		0.0727	0.0660	0.0570	0.0482	0.0617
Heavy water		0.5970	0.5443	0.4876	0.4183	0.5118
L.S.D. (0.05)		0.0121				0.0061
S		K(mg-1)				Mean S
		0	1000	2000	3000	
25		0.2940	0.2197	0.1498	0.1442	0.2019
50		0.3311	0.3212	0.3072	0.2455	0.3013
100		0.3838	0.3745	0.3599	0.3100	0.3571
L.S.D. (0.05)		0.0148				0.0074

Table 5. Effect of water quality, field capacity, potassium concentration and their interactions on cadmium concentration (mg. kg^{-1}) in leaves of wheat plant.

The bilateral interaction between field capacity and potassium significantly affected cadmium concentration, as 25% treatment gave field capacity and the highest potassium concentration, the lowest value of 0.1442mg.kg^{-1}, while the highest value (0.383)mg.kg^{-1} resulted from 100% field capacity treatment without adding potassium. The triple interaction showed a significant effect 0n this characteristic, as the treatment of soft water with a field capacity of 25% and the highest potassium concentration gave the lowest values (0.0343) mg.kg^{-1}, while the highest concentration of cadmium resulted from the treatment of heavy water with a field capacity of 100% without adding potassium (0.6739)mg.kg^{-1}. The rest of the values of the triple interactions came between the two values mentioned above.

Cadmium concentration in grains

It appears from Table 6 that the water quality had a significant effect on the cadmium concentration of wheat grains, as the heavy water treatment was superior, giving 0.2074 mg.kg-1 cadmium compared to the soft water treatment, which gave a value of 0.0311 mg.kg-1. The field capacity also affected This trait, which increased with the increase in the field capacity, and the field capacity 25% treatment had the lowest value of 0.0654 mg.kg-1. In comparison, the 100%

field capacity treatment gave the highest value of 0.1818 mg.kg-1, and the 50% field capacity treatment gave an average value between these values. On the other hand, the cadmium concentration decreased significantly with the increase of potassium added, as the highest value was 0.1607 mg.kg-1 in the control treatment, it decreased to the lowest value of 0.0794 $mg.kg^{-1}$ in the treatment 3000 $mg.l^{-1}$ potassium, the percentage decrease was 50.6% .The bi-interactions significantly affected this trait, as the treatment of soft water with a field capacity of 25% gave the lowest values (0.0253) $mg.kg^{-1}$.

In comparison, the highest value was produced from heavy water with a field capacity of 100%, which gave 0.3243 mg.kg-1. Also, the interaction effect between water quality And potassium was significant, where soft water with the highest potassium concentration gave the lowest value (0.0237) $mg.kg-^{1}$. In contrast, the heavy water treatment without adding potassium gave the highest value(0.2858) $mg.kg^{-1}$.The interaction between field capacity and potassium concentration showed a statistical effect, as the field capacity treatment of 25% and the highest potassium concentration had the lowest value (0.0417) $mg.kg^{-1}$, while 100% treatment gave the field capacity without adding potassium, the highest values (0.2290) $mg.kg^{-1}$.The interaction effect between the three factors under study was apparent in this characteristic, as the treatment of soft water with a field capacity of 25% and 3000 K gave the lowest value (0.0204)$mg.kg^{-1}$. In contrast, the highest value was associated with heavy water treatment with a field capacity of 100% without adding potassium, which amounted to 0.4121 mg. kg^{-1}.

water quality I	field capacity S(%)	K(mg-1)				I× S
		0	1000	2000	3000	
Soft water	25	0.0300	0.0271	0.0235	0.0204	0.0253
	50	0.0350	0.0290	0.0263	0.0247	0.0287
	100	0.0459	0.0441	0.0416	0.0260	0.0394
Heavy water	25	0.1477	0.1319	0.0797	0.0629	0.1055
	50	0.2977	0.2493	0.1110	0.1118	0.1925
	100	0.4121	0.3377	0.3170	0.2303	0.3243
Mean K		0.1607	0.1365	0.0998	0.0794	0.0083
L.S.D. (0.05)		K= 0.0067				
		K × I× S= 0.0165				
water quality I		K(mg-1)				Mean I
		0	1000	2000	3000	
Soft water		0.0370	0.0334	0.0304	0.0237	0.0311
Heavy water		0.2858	0.2396	0.1692	0.1350	0.2074
L.S.D. (0.05)		0.0095				0.0048
field capacity S(%)		K(mg-1)				S
		0	1000	2000	3000	
25		0.0888	0.0795	0.0516	0.0417	0.0654
50		0.1664	0.1392	0.0686	0.0682	0.1106
100		0.2290	0.1909	0.1793	0.1282	0.1818
L.S.D. (0.05)		0.0117				0.0058

Table 6. Effect of water quality, field capacity, potassium concentration and their interactions on cadmium concentration (mg. kg^{-1}) in wheat grains.

The concentration of lead and cadmium (mg.l^{-1}) in water, soil and plant parts:

Table 7 shows the concentration of lead in water, soil, roots, leaves, leaves and grains, where its concentration in water was 0.0817 mg. It was in leaves (3.983) mg/kg and grains (1.991) mg/kg, while the proportions of cadmium in water, soil, roots, leaves and grains were as follows, where its percentage was in water. (0.00308) mg. 1.212) mg. kg-1 ratio in roots (0.5118) mg.

Heavy element	Concentration of the element in water	Concentration of the element in soil	Concentration of the element in roots	The concentration of the element in leaves	Concentration of the element in grains	WHO (2003)
Lead	**0.0817**	15.69	17.380	3.983	1.991	5
Cadmium	**0.00308**	1.212	0.675	0.5118	0.207	0.2

Table 7. The concentration of lead and cadmium (mg.L^{-1}) in water, soil and plant parts.

Discussion

Effect of water quality on cadmium and lead concentration in roots, leaves and grains:

Tables (1,2,3,4,5,6) showed increased concentrations of cadmium and lead. The reason for this is the abundance of these elements in the water, which represents sewage and domestic wastewater as well as factory and agricultural waste, all of which produce high concentrations of elements, especially lead and cadmium, which are included in the manufacturing of fertilizers, pesticides, dyes, industrial waste residues and other sources that seep into heavy water, as well as the role of microorganisms that increase their concentrations as a result of the decomposition of complex organic materials into simple materials, of which mineral elements are a part. Table (7) shows that the concentration of lead in water, soil and plant parts accumulated more than the accumulation of cadmium. Soil, roots, leaves and grains (0.0817 mg. L^{-1},15.69 mg. kg^{-1},17,380 mg. kg^{-1},3.983 mg. kg^{-1},1.991 mg. kg^{-1}) sequentially, where the accumulation of lead in the soil and roots reached the highest value compared to its accumulation in the grains, with an increase of 688.44 and 773.36% respectively. The accumulation of lead in the roots more than the rest of the plant parts is attributed to several reasons, including restriction of movement, immobilization and precipitation of insoluble lead salts in the intracellular domain, accumulation in the plasma membrane and sequestration in the vacuoles of the cells of the cortex and epidermis These results agreed with[12,13,14] indicated that there are types of plants that have a high accumulation of hyperaccumulators that can transfer high concentrations of lead to the leaves without causing damage to the basic metabolic processes. This finding also shows that particular types of plants have a high accumulation capacity of heavy metals, including lead, up to 1000 (ppm). The main reason is due to the plant's tolerance of these high concentrations of lead ions to limit the absorption of the metal and its excretion and linkage with proteins or special bonds. Lead and cadmium exceeded the permissible limit in roots, leaves and grains.

Effect of water stress on lead and cadmium concentrations in roots, leaves and grains:

The results of tables[17,18,19,20,21,22,23] show an increase in the concentrations of the elements with a decrease in the field capacity because the plant was subjected to double stress that affected the ability of the plant to remove and treat pollution with these elements, and this was confirmed by the results of the statistical analysis that there were significant differences between Plants that were subjected to water stress and stress with heavy elements, and that were exposed to element stress only. The higher concentrations of elements in soil compared to roots as well as roots compared to leaves and grains can be attributed to the strategies followed by the plant to reduce the damage of the elements as much as possible as it prevents its entry into the plant and removes harmful concentrations into the soil. On the other hand, if the plant is exposed to stress and elements enter it, it follows another strategy: accumulate elements in the roots and prevent high concentrations of leaves and grains from reaching as much as possible.

Effect of potassium spraying on lead and cadmium concentration:

Potassium is one of the necessary nutrients, and it is a single-charged ketone, thus competing with lead and cadmium for absorbent sites, thus preventing the absorption of these heavy elements. It played an essential role in reducing the stress of heavy elements by reducing lead and cadmium concentrations in all parts of the plant.

Conclusion

It was observed that the accumulation of heavy metals increased with the increase of the field capacity, especially the field capacity of 100%. High potassium levels (above the recommended amounts), especially the level (3000) $mg.l^{-1}$, are essential in mitigating the toxic effect of heavy metals. It was noted that the accumulation of cadmium and lead varied within the different parts of the plant, and their presence in the roots was in high concentrations compared to leaves and grains. It was observed that the accumulation rate of heavy metals (cadmium and lead) in the plant tissues increased with the increase in the period of exposure. Based on the study's results, the treated water can be used to irrigate the wheat crop concerning the danger of containing heavy elements (lead and cadmium), as their concentration did not exceed the permissible limits of the World Health Organization.

References

1 Zhao,W.; Liu,L., , Shen,Q., Yang,J., Han,X., Tian,F., and Wu,J. Effects of Water Stress on Photosynthesis, Yield, and Water Use Efficiency in Winter Wheat.Water **2020**, 12, 2127; doi:10.3390/w12082127. www.mdpi.com/journal/water. Pp.1-19.

2 Bhandari, M.; Baker, S.;Rudd, J.C.; Ibrahim, A.M.H.; Chang,A.; Xue, Q.; Jung, J.; Landivar, J.;Auvermann. Assessing the Effect of Drought on Winter Wheat Growth Using Unmanned Aerial System(U.A.S.)-Based Phenotyping. Remote Sens., , B.**2021**. 13, 1144.https://doi.org/10.3390/rs13061144.

3 Aldesuquy,H.S.; Abbas,M.A., Abo- Hamed,S.A., Elhakem,A.Hand Alsokari, S.S.; Glycine betaine and salicylic acid-induced modification in productivity of two different cultivars of wheat grown under water stress, *Journal of Stress Physiology and Biochemistry*, **2012**. *8(2)* : 72-89.

4 Sharma, P.; Tripathi, S.; and Chandra, R.;Accumulation and histological observation of heavy metal in Brassica campestris L. and Chenopodium album L. Growing on sludge waste of pulp paper industry after secondary treatment. *J. Experiment. Biol. Agric. Sci. 8(3),* 320–333.

5 Mojiri, A.; and H.; Abdul Aziz. Effect of municipal wastewater on accumulation of heavy metals in soil and wheat (Triticum aestivum L.) with two irrigation methods. Romanian Agricultural Research. **2011**. , 222-217 :28.

6 Mojiri, A.; H. Abdul Aziz; Sh.Q. Aziz; A Gholami and M. Aboutorab .Impact of urban wastewater on soil properties and Lepidium sativum in an arid region .*International Journal of Scientific Research in Environmental Sciences,* **2013**.*1(1)* : 7-15 .

7 Al-Jilani, Dr. Abdel-Gawad, "Wastewater Reuse after the Text," Workshop and Expansion in the Establishment of Wastewater Irrigated Fields, Egypt, 2001.

8 Ali, Noureddine Shawqi, Praise be to God, Suleiman Rahi, and Abdel-Wahhab Abdel-Razzaq Shaker. Soil Fertility. Ministry of Higher Education Education. Scientific Books House for printing, publishing and distribution .**2014**.

9 A.P.H.A. (American Public Health Association.Standard methods for examination of water and wastewater.21the Ed. Washington, D.C,.(U.S.A.).**2005**.

10 Alfatlawy,S.Kh. A.; Alwan, A. Alfatlawy,H.J.; Impact of potassium alleviating water stress on wheat plants irrigated with treated water.I:Some vegetative growth characteristics.(under publication).

11 11 Al-Amiri, Najla Jaber Mujamed, Evaluation and reclamation of sewage using different filters and reusing them for irrigation. PhD thesis, College of Agriculture - University of Basra. **2006**.

12 12 -Meyers , D. E. R.; Auchterlonie, G. J.; Webb, R.I. and Wood, B.U.; uptake and localization of lead in the root system of Brassicajuncea. *Environ.* **2008**. *Pollut 153(2*):323–332.

13 13-Liu, X.; Peng, K.; Wang, A.; Lian, C. and Shen, Z. Cadmium accumulation and distribution in populations of Phytolacca americana L. and the role of transpiration. *Chemosphere* **2010**. *78(9):*1136–1141.

14 14-Arshad, M.; Silvestre, J.; Pinelli, E.; Kallerhoff, J.; Kaemmerer, M.; Tarigo, A.; Shahid, M.; Guiresse, M.; Pradere, P. and Dumat,C. Afield study of lead phytoextraction by various scented Pelargonium cultivars. *Chemosphere* **2008**. *71(11):*2187–2192.

15 15-Maestri, E.; Marmiroli, M.; Visioli, G. and Marmiroli, N. Metal tolerance and hyperaccumulation: costs and trade-offs between traits and environment. *E. Exp Bot* **2010** *68(1*):1–13.

Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023
Citation: Al-Fatlawy, S.K.A.A.; Alwan, A.H.; .; Al-Fatlawy, H.J. lead and cadmium in the wheat plant as influenced by water quality, water stress and potassium. Revis Bionatura 2023;8 (1) 100. http://dx.doi.org/10.21931/RB/CSS/2023.08.01.100