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RESEARCH ARTICLE

Effect of foliar spraying with cadmium chloride ($CdCl_2$), oxalic acid and their interactions on some physiological traits of bean (*Vicia faba* L.)

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Abstract

The essay was regulated through the 2022-2023 developing period according to the Randomized complete block design (RCBD) as a working experiment (3×2) with three replications, each replication included 12 pots to examination the event of foliar splash with cadmium chloride ($CdCl_2$) at two concentrations (200 and 300) mg L^{-1} and oxalic acid in assembly (50, 100 and 150) mg L^{-1} on some physiological characteristics of bean plants, If after math show meaningful rising in rising in catalase enzyme activity (44.67 intake unit Ml^{-1}) vitamin C content (87.40 mg 100 gm m^{-1} wet weight) and proline acid content (61.19 µg gm^{-1} fresh mass) also Hydrogen peroxide content (3.20 µg gm^{-1} fresh weight) when plants related at the concentration 300 mg L^{-1} of $CdCl_2$, while there was a significant decline in the average motion of salicylic acid content under the same treatment, as for treating the plant with oxalic acid led to a substantial increase in vitamin c content (85.88 mg 100 gm^{-1} wet weight) proline acid content (73.94 µg gm^{-1} fresh mass) Hydrogen peroxide content (2.70 µg gm^{-1}fresh weight) and salicylic acid content (13.20 µg gm^{-1}) when plant treated at the concentration 150 Mg L^{-1}, while there was a significant decrease in catalase enzyme activity (33.29 intake unit ml^{-1}) at the same concentration. As for the connect between the two essay factors, it had a significant effect on most of the traits studied.

Keywords

amino acids; catalase enzyme; heavy elements; proline; *Vicia faba* L.

Introduction

The bean plant (*Vicia faba* L.) is from Fabaceae; the leaves are pinnate compounds and exchanged on stem flowers consisting of 5 sepals, while the corona contains five petals flag and 2 wings. Legume is pod and include 1-5 seeds and are considered one of the essential economic leguminous crops with high nutritional value because they contain many important elements such as iron, magnesium and potassium, in addition to containing fibre, minerals and some acids (1). Faba beans contain many proteins, carbohydrates, B-group vitamins and minerals (2, 3). Bean cultivation is widespread in many countries, including China and Italy. In France and some countries in Asia and North Africa, the production in Asia and the Pacific is about 2.7 million tons, while in Iraq, the production is 41000 tons (4). The bean plant is rich in estrogenic compounds, which make up the bulk of the plants' weight, as well as vitamins, minerals and manganese, which have a role in protecting the body from cancerous diseases, diseases of the nervous and digestive systems and blood diseases and maintaining body weight, in addition to using its green leaves as fodder for animals (5, 6).

The plant is exposed to various types of stresses, especially abiotic stresses, including exposure to heavy elements, which leads to physiological and biological changes in the plant. These changes are among the fundamental obstacles to crop productivity and quality due to the toxic effects of these elements on the plant through their competition with some nutrient elements in the soil, including phosphorus and zinc and their interaction with a group (SH) and its production of free oxidative radicals, thus damaging cellular molecules and affecting the synthesis and function of proteins (7). Cadmium chloride ($CdCl_2$) is a chemical compound with a molecular formula of Cadmium chloride and a molecular weight of 183.32 g mol^{-1}. It is in the form of white crystals that are soluble in water. Cadmium is a trace element released into the environment from various anthropogenic activities such as agricultural, industrial and mining processes and exhaust gases from transportation means (8). It is a highly toxic element that lifetime exposure to low levels of Cadmium may cause severe damage to human health (9).

The heavy elements have high density and may be toxic or not toxic and these elements are found naturally in the earths' crust or plant compost waste in low concentrations. Heavy elements accumulate in organisms' bodies and when their concentrations are high, their body decay becomes very toxic. Also, these elements harm most of the plants' phenotypic and physiological activities as a result of their impact on the expansion and division of plant cells due to the accumulation of free radicals, including the (OH^-, O^{-2} and H_2O_2) in plant cell walls, as well as the effect of this element on the growth of root cells, thus causing poor absorption of nutrients and essential elements from the soil and affecting the gene expression process of the cells (10). Oxalic acid, with the chemical formula of $H_2C_2O_4$, is an organic acid found in various plants such as tomatoes, spinach, tea and others. It is found in colourless solid crystals and is soluble in water. This acid is produced through the oxidative breakdown of some compounds, such as carbohydrates and proteins and may be found in non-alcoholic salts. It is dissolved in the calcium element, which hinders calcium absorption and its use in the diet. This acid also contributes to the presence of some essential nutritional components such as phosphorus, magnesium and iron by converting them into insoluble salts and compounds (11). The plant performs many processes, including aerobic respiration, photorespiration, or oxaloacetate breakdown due to the presence of the Oxaloacetates enzyme, through which oxalic acid is produced in the plants (12).

Oxalic acid exploits an essential function in protecting the plant from the toxic effects of weighty metals such as Cadmium, nickel, zinc and others, which positively affects the plants vegetal and root enlargement rate and thus its intake of nutritive for its growth from the soil. In addition, this acid curbs the harmful event of free radicals and regulates the growth process: cellular, gene expression and prevention of phenol oxidation (13) .In light of the previous data, this study aimed to know the effect of Cadmium on the physiological characteristics of bean plants and the function of oxalic acid in reducing the harmful event of this metal.

Materials and Methods

The experiment was conducted for the 2022-2023 agricultural season according to the Randomized complete block design (RCBD) (14) as a working experiment (3x2) with three replications. The essay involves the following aspects:

1. Two assemblies of cadmium chloride $CdCl_2$ are 300 and 200 mg L^{-1}.
2. Three concentrations of oxalic acid are 50, 100 and 150 mg L^{-1}.

Each replicate included 12 pots, as the figure of pots in the experiment was 36.

Pea grains were planted on fifteen October 2022. Fifteen seeds were seeded in any pot with a depth of 1 cm. The diameter of one pot was 23 cm, its height was 22 cm and its weight was 5 Kg.

Table 1. A few chemical and physical characteristics of dirt

Character	Value	Unit
EC	2	$dS.m^{-1}$
N	60	mg kg^{-1}
P	5	mg kg^{-1}
K	180	mg kg^{-1}
Clay	250	g kg^{-1}
Sand	220	g kg^{-1}

chloride with a manual pressure sprayer and early in the morning, after preparing it by taking 1 gm of $CdCl_2$ and dissolving it with 1000 ml of distilled water, then the concentrations used in the study were destined award to the C_1V_1 alleviation law. $=C_2V_2$. The oxalic amino acid was sprayed on the plant at the same time using a manual pressure sprayer after preparing it by dissolving 1g of oxalic acid in 1000 ml of distilled water, from which the concentrations used in the study were destined award to the dilution law $C_1V_1=C_2V_2$.

Studied characteristics

Estimating the effectiveness of the catalase enzyme (absorption unit. ml^{-1}) in plant leaves

1gm of fresh plant leaves was mashed and 10 mL of K_2HPO_4 solution (M 0.1) was added to it. Then, the samples were sprayed the leaves and situated in a refrigerated separator at 4 °C for thirty moments at a velocity of one thousand revolutions min^{-1} .

The solutions used in the study were prepared as follows:

Solution A: Prepare 1.8 grams of buffer K_2HPO_4 and resolve it in a quantity of extract water, then accomplish the extent to 200 mL of extract water .

Solution B: Prepare with weighing 1 g of buffer K_2HPO_4 and dissolving it in a few quantities of distilled water, then fill-up the extent to 200 mL of extract water .

K_2HPO_4 solution (50) mmol: Prepare this solution by taking assured size of sol B and adding it to solution A (50) till the PH price reaches = 7.

H_2O_2 solution: Prepare by taking 0.3 mL of H_2O_2 (30%) and supplement with 100 ml of buffer K_2HPO_4. 0.1 mL of the sample was taken and 1.9 mL of buffer solution and 1 mL of H_2O_2 solution were added. It was shaken well. Then, the trap amount was scanned with a UV-pyrometer at 240 nm. The amount of change in absorbance was monitored every half minute for three minutes and the force was planned in a similar style. However, lacking attaching the selection, the enzyme activity was guessed according to the way presented by and relative to equation 1 (15):

Enzyme activity (absorption unit ml^{-1}) = (Δ Read device/ Δ Time)/0.1×0.01 (Eqn. 1.)

0.1 = Specimen extent (mL).

0.01= The amount of enzyme that causes an increase in light absorption per minute at a wavelength of 450 nanometers.

Vitamin C content (mg. 100 gm^{-1} wet weight) in vegetable leaves

gram of plant leaves was weighed and 10 mL of oxalic acid (0.05 M) was added to it. The samples were then filtered after being placed in the dark for 24 hours. The sols were destined as follows:

Sol A: Weight 5 g of Ammonium molybdate and dissolve it in 100 mL of distilled water.

Solution B: Take a gravity of $C_2H_2O_4$ (0.05), award to the rule of molarity. Determine the required weight and mix it with (EDTA) ($C_6H_{16}N_2O_8$) (0.02 M). In the same way, determine the required weight, then accomplish the ton to 100 mL with extract water.

Sol C: 5g of Metaphosphoric acid was dissolved in 100 mL of dripped water after withdrawing 30 mL of the solution, mixing it with 80 mL of Acetic acid and supplementing with 500 mL of distilled water.

2mL of the filtrate was taken and 2 mL of solution B, 1 mL of solution C, 0.5 mL of solution D and 2 mL of solution A were added. The ton was accomplished with 25 mL of dripped water and the absorbance was measured at a wavelength of 760 nm. Then, a standard curve was prepared with a weight of 0.1 g of acid and solved with 100 mL of oxalic acid, drew 0.5, 1, 2, 3, 4 and 5 mL from the curve and added to these concentrations. Then, he took a beaker and put 0.5 ML of solution D, 1 mL of solution C and 2 mL of solution A in it. The volume was accomplished with dripped water and the absorbance was estimated at the wavelength of 760 nm, then drawing the standard curve inter the condensations of the vitamin and the optical density rates for any concentration, as the curve was used to draw the relationship and calculate the values of vitamin C (16).

Proline acid matter (μg g^{-1} fresh mass) in plant foliates

Weigh 0.5 grams of fresh plant leaves and add 10 mL of Sulfosalicylic acid at the assembly of 3% .The plant selections were crushed and discrete with a separator. Pick 2 mL of the clarify and collect it 2 mL of glacial acetic acid and 2 mL of Ninhydrin solution (prepared with dissolving 1 g of ninhydrin with 30 mL of glacial acetic acid and 20 mL of 6 M phosphoric acid) and leave the mix on minimal warmth till the saffron pigment appears, then require the ducts were placed in a water bath at 100 °C for 60 min until the colour of the mixture changed to red. Then, the samples were cooled in the ice bath and 4 mL of toluene was added.

A red pigment stratum was observed to rise to the top in the tubes. After that, 3 mL of this coloured layer was withdrawn and weighed using a Spectrum Lab 22 device with a wavelength of 520 nm. Proline was estimated in the samples according to the standard method as given in Equation 1(17). According to the following equation:

Proline = (Read device ×20/ Sample weight) × 1.47 (Eqn. 2.)

H_2O_2 import in plant leaves (μmol g^{-1} wet weight)

1 gram of plant leaves was crushed in a ceramic mortar after adding 2 mL of Trichloro acetic acid (0.1%) to the samples. After filtering them, they were placed in a centrifuge for 15 min at 12000 revolutions $min^{-1.}$ The solutions used in the study are:

K_2HPO_4 solution (0.010 M): This solution was planned by adding a specific size B to solution A (200 mL) until the reaction reached pH = 7. Solutions A and B were scheduled as follows:

Solution A: It was planned to resolve 0.3 g of K_2HPO_4 in a small water container, then fill the volume to 200 mL of extract water.

Solution B: It was planned to resolve 0.2 g of K_2HPO_4 in a small water container, then fill the volume to 200 mL of extract water.

KI (1 M) solution: It was planned to resolve 33.2 mL of KI with a bit of distilled water, then complete the size to 200 mL of dripped water.

H_2O_2 solution (0.010 M): planned with dissolving 0.1 mL of peroxide hydrogen in a few amounts of water. Thereafter add the size to 200 mL of dripped water .Take 0.5 mL of the filter and add 1 mL of KI solution and 0.5 mL of K_2HPO_4 solution to it. As for the Blank treatment, it contains 1 mL of K_2HPO_4 and does not contain the plant selections. After this, the plant selection was taken and placed in a pyrometer at a wavelength of 390 nm and the amount of H_2O_2 was calculated. Using diluted solutions (0.5, 1, 3, 7 and 9), micromole mL^{-1} using the standard curve, then 0.5 mL of each diluted solution was withdrawn and added to the reactant and measured with a pyrometer at the same wavelength. After that, the H_2O_2 standard curve was pulled, which agreed with the selections' optical density, which was measured with the pyrometer and thus the selection content was guessed. H_2O_2 relative to the way presented (18).

Salicylic acid matter (μg ml^{-1}) in plant foliates

One gm. of plant leaves was taken and set in the freezer for one day, then they were squashed and 100 mg of these selections were possessed and filtered with a separator for 10 min at a speed of 1000 revolutions min^{-1}, then 100 microliters were withdrawn from each selection and 3 mL of $FeCl_3$ was inserted to it until the violet pigment appeared and the intake was guessed. Using a visible pyrometer at a wavelength of 540 nm, then the standard detour was pulled and the plant content of this acid was guess with contrasting the intake of any assembly by the standard detour and relative to the way (19).

Statistical analysis

This study was statistically formed according to the (RCBD) method to determine the effect of various factors on the studied subjects and the arithmetic means were compared with the Least significant difference (LSD) at the following level of 0.05.

Results

Motion of the catalase enzyme

The cadmium chloride, particularly the assembly of 300 mg $L^{-1,}$ allows the high meaning full average for the trait (44.67 absorption unit mL^{-1}), contrast to the force (30.95 absorption unit. mL^{-1}) (Table 2) with a rate rising of 44.32%. Table 2. shows the meaningful decrease in the middle of that type. At the same time, the plant is processed with oxalic acid, particularly the assembly of 150 mg L^{-1}, which allows the lowest average at the traits, amounting to 33.29 absorption units mL^{-1} contrast to the force, which amounts to 40.62 absorption unit mL^{-1}, with a percentage decrease of 18.00%. The list too put the meaningful effect of the connection among the two essay factors on the average of this trait, particularly the two assemblies of 300 mg L^{-1} of Cadmium chloride and 0 mg L^{-1} of oxalic acid, which allow the height average of 53.44 absorption unit mL^{-1} contrast to the lowest average of 28.80 absorption unit mL^{-1} at two concentrations of 0 mg L^{-1} of Cadmium chloride and 100 mg L^{-1} of oxalic acid.

Table 2. The event of foliar splashing with cadmium chloride and oxalic amino acid and their interactions on the motion of the catalase enzyme (intake unit mL^{-1}) of bean plants

Oxalic amino acid (mg L^{-1}) (O)	Cadmium chloride (mg L^{-1}) (C)			Mean O
	0	200	300	
0	33.67	34.74	53.44	40.62
50	33.44	34.09	43.44	36.99
100	28.80	31.77	41.12	33.90
150	27.90	31.30	40.67	33.29
Mean C	30.95	32.97	44.67	
L.S.D(0.05)	O= 1.93	C=1.67	O×C=3.34	

Vitamin C content

The results show that there was a meaningful rise in the average content of vitamin C in the leaves when treated with cadmium chloride, particularly the assembly of 300 mg L^{-1}, which allows the high average of 87.40 mg100 g^{-1} wet weight contrast to the force, who equal to 63.44 mg100 g^{-1} wet weight (Table 3). With a rate excess of 37.76%. The oxalic acid, especially the assembly of 150 mg L^{-1}, allowed the high statistically significant average of 85.88 mg100 g^{-1} wet weight in contrast to the force, which amounted to 69.56 mg100 g^{-1} wet weight, with a rate increase of 23.46%, The interaction also had the meaningful event on the average of this trait, especially the two concentrations of 300 mg L^{-1} of Cadmium chloride and 100 mg L^{-1} of Oxalic acid, which allow the high average of 100.87 mg100 g^{-1} fresh mass, contrast to the low average of 52.44 mg 100 g^{-1} fresh mass at concentrations of 0 mg L^{-1} of Cadmium chloride and 100 mg L^{-1} of oxalic acid.

Table 3. Event of foliar splashing with cadmium chloride and oxalic amino acid and their interactions on the vitamin C content (mg 100 gm^{-1} wet weight) of bean plants

Oxalic amino acid (mg L^{-1}) (O)	Cadmium chloride (mg L^{-1}) (C)			Mean O
	0	200	300	
0	55.27	74.00	79.40	69.56
50	65.70	79.40	78.75	74.62
100	52.44	93.10	100.87	82.14
150	80.34	86.72	90.60	85.88
Mean C	63.44	83.30	87.40	
L.S.D(0.05)	O= 2.31	C=2.00	O×C=4.00	

Proline acid content

The results of Table 4 involve a meaningful rise in the average of that type when the plant was cured by cadmium chloride, particularly the trait of 300 mg L^{-1}, which allows the highest average of 61.19 micrograms. gm^{-1} wet weight compared to the rule, which equals 56.94 micrograms. gm^{-1} wet weight, with a rate rising of 7.46%. The Table 4 also indicated that there was a statistically significant increase when treating the plant with oxalic acid, particularly the trait of 150 mg L^{-1}, which allowed the highest average (73.94 micrograms g^{-1} fresh weight) compared to the control (51.16 micrograms g^{-1} fresh weight), by a rate increase of 44.52%. The interaction also had a meaningful event on the average of that trait, especially the two concentrations of 200 mg L^{-1} of Cadmium chloride and 150 mg L^{-1} of oxalic acid, which allowed the highest average of 82.80 micrograms g^{-1} wet weight, while the lowest average of the type run to 52.12 micrograms g^{-1} of fresh mass, when dealing with control.

Table 4. Event of foliar splashing with cadmium chloride and oxalic amino acid and their interactions on the proline acid content (μg gm^{-1} fresh mass) of bean plants

Oxalic amino acid (mg L^{-1}) (O)	Cadmium chloride (mg L^{-1}) (C)			Mean O
	0	200	300	
0	52.12	41.19	60.16	51.16
50	53.41	54.70	54.43	54.18
100	54.68	57.25	58.70	56.88
150	67.56	82.80	71.47	73.94
Mean C	56.94	58.18	61.19	
L.S.D(0.05)	O= 2.07	C=1.80	O×C=3.59	

Hydrogen peroxide content

The concentration of cadmium chloride (300 mg L^{-1}) allows the highest average for the trait, equaling 3.20 micromole g-1 fresh mass, contrasting the force, which equalled 2.21 micromole g^{-1} fresh mass (Table 5). A rate excess of 22.17%. The concentration of oxalic acid (150 mg L^{-1}) gave the highest rate from the type (2.70 micromole g^{-1} fresh mass), compared to the rule, which (2.21 micromole g^{-1} fresh weight), with an increased percentage. It is 22.17%. Table 5 also shows a meaningful event of the connect on the average of that trait, especially the two concentrations of 300 mg L^{-1} of Cadmium chloride and 50 mg L^{-1} of Oxalic acid, which allow the highest average of 3.78 micromole g^{-1} wet weight, contrasted to the lowest average of 1.28 micromole g^{-1} fresh mass at two concentrations of 0 mg L^{-1} of Cadmium chloride and 50 mg L^{-1} of Oxalic acid.

Table 5. The event of foliar splashing with cadmium chloride and oxalic amino acid and their interactions on the hydrogen peroxide content (μmol gm^{-1} fresh weight) of bean plants

Oxalic amino acid (mg L^{-1}) (O)	Cadmium chloride (mg L^{-1}) (C)			Mean O
	0	200	300	
0	1.76	2.11	2.77	2.21
50	1.28	2.47	3.78	2.51
100	2.44	2.45	3.12	2.67
150	2.50	2.47	3.12	2.70
Mean C	1.99	2.37	3.20	
L.S.D(0.05)	O=0.35	C=0.31	O×C=0.61	

Salicylic acid content

The results of Table 6 involve a meaningful decrease in the average plant import of salicylic acid when processed by cadmium chloride, particularly the trait of 300 mg L^{-1}, which allows the lowest average of 8.05 micrograms ml^{-1} contrast to the force, which amounted to 11.96 micrograms ml^{-1}, with a percentage decrease of 32.69%. The rate of this type was statistically significant when the plant was cured by oxalic acid, particularly the trait of 150 mg L^{-1}, which allowed the highest average of 13.20 micrograms ml^{-1} contrast to the force, which amounted to 5.82 micrograms ml^{-1}, with rate increase of 126.8%. The interaction also has a meaningful effect on that trait's average if the two traits are zero mg L^{-1} of Cadmium chloride and 150 mg L^{-1} of Oxalic acid. The highest average was 16.90 micrograms ml^{-1} compared to the lowest average of 5.69 micrograms mL^{-1} at the two concentrations of 300 mg L^{-1} of Cadmium chloride and 0 mg L^{-1} of Oxalic acid.

Table 6. Event of foliar splashing with cadmium chloride and oxalic amino acid and their interactions on the salicylic acid content (μg ml^{-1}) of bean plants

Oxalic amino acid (mg L^{-1}) (O)	Cadmium chloride (mg L^{-1}) (C)			Mean O
	0	200	300	
0	5.88	5.90	5.69	5.82
50	8.44	7.17	7.06	7.55
100	16.60	9.58	8.14	11.44
150	16.90	11.40	11.29	13.20
Mean C	11. 96	8.51	8.05	
L.S.D(0.05)	O= 1.89	C=1.64	O×C=3.28	

Discussion

Motion of the catalase enzyme

The cadmium chloride due to its effect on plant growth, expansion, absorption of necessary elements and the membrane structure of the plant cell due to the conditions of oxidative stress generated within the plant by Cadmium chloride, which is represented by an increased concentration of free radicals, including H_2O_2, OH^-, O^{-2} (20). The plant works to raise its defence mechanism to resist such unfavourable conditions, including increasing its internal content of antioxidant enzymes. This is due to the effect of the plants' higher absorption of some elements, including Ca^{2+}, which may interfere with the plants' absorption of other components, such as iron, as a result of the antagonism process between the ions involved in the structure of the Catalase molecule (21). This affects the activity and effectiveness of this enzyme when treated with oxalic acid. The list too put a meaningful effect of the connection among the two essay factors on the average of this trait, particularly the two assembly of 300 mg L^{-1} of Cadmium chloride and 0 mg L^{-1} of oxalic acid, which allow the high average of 53.44 absorption units .ml^{-1} contrast to the lowest average of 28.80 absorption units .ml^{-1} at two concentrations of 0 mg L^{-1} of Cadmium chloride and 100 mg L^{-1} of oxalic acid.

Vitamin C content

Cadmium chloride may be due to the stress conditions generated by the action of cadmium chloride, as cadmium is a heavy and toxic element that harms the vitality and effectiveness of cellular organelles such as stems and roots and the oxidation of plant membranes (22) .This increases the production of free radicals when the plants' defence, represented by non-enzymatic antioxidants, including vitamin C, is transmitted to it .Oxalic acid is an organic acid that controls the plants' physiological activities and protects cellular parts from the toxic effects of heavy metals. This increases the plants' internal resistance to the impact of oxidative conditions generated by stress, thus supporting the plant parts, including the roots and their absorption of nutrients from the soil, as it is a chelating acid that combines with toxic elements to reduce their toxicity (23). Here, it increases the plants' resistance to unfavourable conditions by increasing its non-enzymatic antioxidants, involving vitamin C.

Proline acid content

Cadmium chloride increases the levels of oxidative stress within plant cells due to the toxic effects of Cadmium on the cellular and physiological level of the plant, causing poor absorption of nutrients by the roots, a decrease in the rate of photosynthesis and transpiration and damage to cell membranes. Enzymes and increased activity of enzymatic and non-enzymatic antioxidant compounds involve proline acid (24). oxalic acid function protects the plants' cellular parts as it regulates the processes of respiration, oxidation and reduction and suppresses the negative effects resulting for the stresses to whom the plant is uncovered. In addition to being a provider of calcium, which is essential in building the plants' cellular membranes, it provides support and protection for the plant. It thus acts as a catalyst to increase the activity and effectiveness of non-enzymatic antioxidants, including proline acid (25). This result agrees with the *Zea mays* plant (26).

Hydrogen peroxide content

Cadmium chloride due to the stress conditions generated inside plant cells due to cadmium chloride since the cadmium element negatively affects the plants' physiological activities, including its vital functions and oxidation processes inside the cells as a result of its combination with some elements, including oxygen and nitrogen, in addition to its effect on the construction of proteins and the transmission of cellular instructions and the process of cellular expansion because it works to accumulate H_2O_2 in plant cells, causing them to harden (27) .oxalic acid due to its role in regulating the plants' calcium content, which is necessary in building cell walls, removing the toxicity of heavy elements, including Cadmium and increasing the plants' oxygen content (28). Combining oxygen with water inside plant cells increases the plants' content of the H_2O_2 molecule, which affects the plants' physiological activities and cell membranes due to the small size of the atoms and the velocity of its spread (29,30) .

Salicylic acid content

Cadmium is a heavy element that stimulates stress conditions in plants by increasing cell membranes' oxidation in the presence of free harmful radicals, in addition to its effect. It affects the growth rate of roots and stems through its work to reduce the absorption of essential elements and nutrients, inhibit the process of photosynthesis, stabilize CO_2 and reduce the activity and effectiveness of non-enzymatic antioxidant compounds, including salicylic acid (31). The function of oxalic acid is to raise the plants' resistance to the stress conditions they are exposed to by providing the necessary calcium element in building cell membranes and its role in curbing the negative effect of Programmed Ros Cell elements. death in plant tissues, which works to increase the plants' growth rate, build its necessary enzymes, increase its non-enzymatic antioxidant content and regulate the plant's ionic balance process (32).

Conclusion

We conclude from this experiment that the use of foliar splashing with cadmium chloride at increasing concentrations, especially the trait of 300 mg L^{-1}, had a stimulating effect on the plants' content of enzymatic and non-enzymatic oxidation inhibitor, including the motion of the catalase ferment and its import of vitamin C, proline acid and H_2O_2, except its salicylic acid content. Likewise, increased concentrations of oxalic acid led to an increase in the plants' matter of non-enzymatic oxidation inhibitor (vitamin C, proline acid, H_2O_2 and salicylic acid), except the plants' activity of the catalase enzyme.

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Authors' contributions

SFM, MDY and FAH conducted the experiment study collected data for conducting the research, SHG analyzed the data for the research statistically. Finally, it was read by the research reviewers and approved by all researchers.

Compliance with ethical standards

Conflict of interest: There is no conflict of interest between the investigators

Ethical issues: None

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