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The alleviation activity of selenium against cadmium phytotoxicity in date palm *Phoenix dactylifera* L.

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Abstract

A laboratory experiment has been performed to investigate possible beneficial role of selenium (Se) in alleviation of cadmium (Cd) toxicity. Date palm *Phoenix dactylifera* L. offshoots at three years old were subjected to individually Cd at two concentrations (3 and 9 $mg.kg^{-1}$) or simultaneously with Se at 1 and 15 $mg.kg^{-1}$. Results show that, Cd treatments alone led to increased accumulation of malondiladehyde (MDA), H_2O_2, proline and peroxidase (POD) activity, per contra, reduction chlorophyll content, chlorophyll stability index (CSI) and membrane stability index (MSI), particularly at high concentration. Cd phytotocixity was alleviated when added at same time with Se at 15 $mg.kg^{-1}$, no significant effect was recorded of Se at 1 $mg.kg^{1}$ to negative effects of Cd even at low concentration. MDA increased 62.72 and 53.05%, H_2O_2, 56.99 and 43.57%, proline 71.35 and 57.16%, POD activity 45.59 and 36.93% while the reduction of chlorophyll a was 31.66 and 11.90%, chlorophyll b 12.78 and 7.76%, total chlorophyll 23.32 and 10.66%, CSI 23.42 and 10.93% and MSI 31.87 and 25.79% for alone Cd at 9 $mg.kg^{-1}$ or with Se at 15 $mg.kg^{-1}$ treatments respectively, compared to control plants.

The results of this study reported the addition of Se at 15 $mg.kg^{-1}$ led to alleviated Cd toxicity in date palm plants.

Keywords: Date palm, Heavy metal, mitigation, phytotoxicity, Selenium

Introduction

Soils pollution with toxic heavy metals is an environmental problem that threats all living organisms (Nascimento and Xing, 2006). Cadmium (Cd) is one of the most harmful and widespread pollutants in agricultural soils (Lin *et al*., 2012), with no metabolic function, but it has adverse effect (Tran and Popova, 2013), including oxidative damage to cellular pathways such as photosynthesis and respiration, due to enhance the generation and accumulation of reactive oxygen species (ROS) (Yadav, 2010). Selenium (Se) is considered to be an important trace element with multiple roles in higher animals and human (Rayman, 2000; Schrauzer, 2009). Although, Se is not confirmed to be required by higher plant (Terry *et al*., 2000), but some findings suggest that, Se which play a novel role in plant biology (Hatfield *et al*, 2014; Wu *et al.*, 2016), including growth promoting activities, improving yield and quality and increase plant resistance against oxidative stresses (Pukacka *et al.*, 2011; Hasanuzzaman *et al*., 2012; Pezzarossa *et al*., 2014). Moreover, plants grown in Se-enriched media showedan obvious resistance to certain abiotic stress, such as, salinity, drought and heavy metals (Hawrylak-Nowak, 2009; Ahmed *et al*., 2016; Wu *et al*., 2016).Exogenous Se application reduced Cd concentration , ROS accumulation and nutrients balanced in rice *Oryza sativa* L. leaves (Lin *et al.*, 2012), also Wu *et al.*(2016) reported that, the supplyingthe media with Se reduced Cd and Pb concentrations in root and shoot of oilseed rape, furthermore, alleviated the negative effect of Cd and Pb on growth and led to decrease oxidative damage.Alyemeni *et al*. (2017) was found that application of Se (10 µM) mitigated the negative effect of Cd on photosynthetic pigments content, leaf relative water content and other physiological attributes of tomato, further Se enhanced antioxidant enzymes including Superoxide dismutase, Catalase, Ascorbate peroxidase and Glutathione reductase, also osmolytes such as, proline, glycine and betaine.Although, Se is useful for plant, high concentrations from Se may be toxic for it. Depending upon species and available concentration of Se in soil, plants vary in accumulation of Se (Kaur *et al.*, 2014). Ryegrass *Lolium perenne* L. plant showed oxidative stress at 10 $mg.kg^{-1}$ Se in soil (Hartikainen *et al*., 2000), while total dry matter yield of *Brassica napus* L. was decreased significantly when Se was added at 0.4 $mg.kg^{-1}$ to soil (Sharma *et al*., 2010).To the best our knowledge, no previous studies of exogenous Se application to date palm *Phoenix dactylifera* L. This study was conducted to investigate the potential effect of Se, and it's of Se under Cd stress.

Materials and Methods

A laboratory experiment under laboratory condition was conducted on date palm offshoots Sayer cultivar at three years old, offshoots cultured in pots (25 cm diameter, 35 cm depth, 6 $kg.pot^{-1}$ soil) filled with soil, with chemical, pH=7.35; Ec=4.84 $ds.m^{-1}$; CEC=8.16 cmole and Organic matter= 0.79%. Soil texture was loam (silt=42.72; sand=34.73 and clay=22.55).Cd as $CdCl_2$ and Se as Na_2SeO_4 were added through irrigation water at two concentrations, Cd at 3 and 9 $mg.kg^{-1}$ and Se at 1 and 15 $mg.kg^{-1}$. These concentrations of Cd and Se were selected based on the highest and the lowest concentrations in soil of Basra governorate-Iraq, according to Al-Jabary *et al.* (2016) for Cd and Al-Tammemi *et al*. (2016) for Se. Treatments are applied as follow:

1- Control: irrigated with water only.
2- Cd3: Cd added at 3 $mg.kg^{-1}$.
3- Cd9: Cd added at 9 $mg.kg^{-1}$.
4- Cd3+Se1: Cd added at 3 $mg.kg^{-1}$ and Se at 1 $mg.kg^{-1}$.
5- Cd3+Se15: Cd added at 3 $mg.kg^{-1}$ and Se at 15 $mg.kg^{-1}$.
6- Cd9+Se1: Cd added at 9 $mg.kg^{-1}$ and Se at 1 $mg.kg^{-1}$.
7- Cd9+Se15: Cd added at 9 $mg.kg^{-1}$ and Se at 15 $mg.kg^{-1}$.

The Plants were irrigated as field capacity by RO (reverse osmosis) water, no detectable concentration of Cd was recorded when soil analyzed before treatment application. Experiment was carried out in complete randomized design with triplicate for each treatment. Means statistically compared by LSD test at $P<0.05$ level. The plant leaves sampling was done after 120 days from trial start on 1 June 2017, for biochemical analysis as follow:

Chlorophyll content

For chlorophyll content analysis, 0.2 g of fresh leaves were ground using a pestle and mortar in 80% acetone, then centrifugation at 3000 rpm for 30 min., supernatant was used to determine chlorophyll content spectrophotometrically according to Arnon (1949) method. Absorbance were read at 645 (A_{645}) and at 663 (A_{663}). Concentrations of chlorophyll a, chlorophyll b and total chlorophyll calculated by the following equations according to Asra-Boamah *et al*. (1986) and values expressed in $mg.g^{-1}$ fresh weight.

$$chl\ a = 12.7(\mathrm{A663}) - 2.69(A645) * V * W$$
$$chl\ b = 22.71(\mathrm{A645}) - 4.68(A663) * V * W$$
$$Totoal\ Chl = 20.2(\mathrm{A645}) + 8.02(A663) * V * W$$

Where V= volume of sample; W= weight of sample

Chlorophyll stability index (CSI)

Chlorophyll stability index was calculated following equation according to Sairam*et al*. (1997):

$$CSI\ (\%) = \frac{Total\ chlorophyll\ in\ treatment}{Total\ chlorophyll\ in\ control} * 100$$

MDA content and Membrane stability index (MSI)

The level of lipid peroxidation in date palm leaves were estimated by MDA content. The concentration of MDA was determined according to Heath and Packer (1968). A 0.5 g of fresh sample was homogenized in 5 ml of Trichloroacetic acid (TCA) (0.1%, w/v), then the homogenate was centrifuged at 10000 for 5 min, 1 ml of supernatant added to 4 ml of thoibaributric acid (TBA; 0.5%, w/v) prepared in 20% TCA, was boiled for 30 min, the mixture placing on ice to termination the reaction. Then absorbance read at 532 nm and 600 nm. MDA concentration calculated by following equation:

$$MDA\ (\mu mole/g) = \frac{1000(A532 - A600)}{155}$$

Which 155 is Extinction coefficient of MDA.

Membrane stability index (MSI) was measured according to Lutts*et al*. (1996). A 0.25g of fresh leaves were cut into small parts, homogenized in 10 ml deionized water, and then incubated on rotary shaker for 24 h. at room temperature. The electric conductivity (C1) of the homogenate was measured. The second electric conductivity (C2) was measured after

placing sample in an oven at 90^o for 2 h, to expel electrolytes, and then cooled it at 25^o. MSI was calculated using following formula:

$$MSI\ (\%) = \left(1 - \frac{C1}{C2}\right) * 100$$

Proline content

Proline content was determined according to Bates *et al.*(1973). A 0.5g of fresh leaves of date palm were homogenized in 10 ml 3% aqueous Sulfosalicylic acid, followed by centrifugation at 6000 rpm for 5 min, 2 ml of glacial acetic acid and 2 ml of acid ninhydrine were added to 2 ml of supernatant in new test tube, the mixture was heated at 100^o C for 1 h, the mixture was placed on ice to stopping reaction. Then 4 ml of toluene was added to mixture and stirred well for 30 seconds. The chromophore containing toluene was separated and absorbance was measured at 520 nm against a toluene blank, and L-proline was used as standard curve.

H_2O_2 and peroxidase activity

Hydrogen peroxide level was determined according to Sergeiv *et al*. (1997). A 0.5 g of leaf was homogenized in an ice bath with 5 ml 0.1 % (w/v) of TCA. The homogenate was centrifuged at 13000 for 15 min, 1 ml of Potassium Iodide (KI) 1 M and 0.5 ml of 10 mM Potassium phosphate buffer (pH 7.0) was added to 1 ml of supernatant. The absorbance was measured at 390 nm. H_2O_2 was used as a standard curve.

Peroxidase (POD) activity was determined in date palm leaves; enzyme was extracted according to Zouari *et al*.(2016). A 0.5 g of fresh leaves were mixed with 0.8 ml of Potassium phosphate buffer (pH 7.0) containing 0.1 mM of ethylene diamine tetraacetic acid (EDTA), 3.75% PVP and 1 mM of phenyl methyl sulfonyl fluoride, then centrifugation at 13000 rpm for 15 min. Then enzyme activity was measured according to the method of Kim and Yoo (1996). Each single unit of peroxidase catalyzed the oxidation of guaiacol in 1 min (U/min/g). The variations in the absorption of tetraguaiacol formation were measured at 470 nm.

Results and Discussion

Chlorophyll content

Chlorophyll a, chlorophyll b and total chlorophyll contents in date palm leaves after 120 daysof exposure to Cd at 3 and 9 mg.kg^{-1}alone or with Seat1 and 15 mg.kg^{-1} are presented in Table 1. The results showed that, the supplementation of Cd individually reduced the chlorophyll content, especially at high concentration, the increasing in Cd concentration led to significant reduction in chlorophyll a from 4.20 to 2.87 mg.g^{-1}, chlorophyll b from 1.33 to 1.16 mg.g^{-1} and total chlorophyll from 5.53 to 4.03 mg.g^{-1} for control and Cd 9 mg.kg^{-1} treatments respectively. When Se supplied simultaneously with Cd, the results elucidated that, Se treatment (1 mg.kg^{-1}) did not significantly influence in chlorophyll content compared to individually Cd treatments at 3 and 9 mg.kg^{-1}, while 15 mg.kg^{-1} Se treatment reduced Cd toxic effect, which chlorophyll a increased about 17.91 % and 22.43%, chlorophyll b 1.56% and 6.45%, total chlorophyll 14.04% and 18.42%, compared to Cd treatments at 3 and 9 mg.kg^{-1} respectively.Regarding chlorophyll stability index (CSI), results in Fig. 1 proved that, date palm exposed to Cd stress showed a significant reduction in CSI, whichCSI reduced from 100% in control treatment to 84.09 and 76.58 %

in alone Cd treatments at 3 and 9 mg.kg^{-1} respectively. While CSI reduced up to 97.97 and 89.07 % when Se added at 15 mg.kg^{-1} with Cd at 3 and 9 mg.kg^{-1} respectively.

The results demonstrated that, the chlorophyll content in date palm plants grown in Cd-contaminated soil was significant decline; the collapse of chlorophyll under Cd stress was reported to date palm plants (Abass *et al*., 2016; Zouari *et al*., 2016) and numerous plants (Gupta *et al*., 2013; Zhang *et al*., 2014; Gomes *et al.*,2015). The collapse of chlorophyll in young date palm leaves could be result of effective role of Cd in inhibition chlorophyll biosynthesis enzymes such as δ-aminolevulinic acid or enhancing chlorophyll degrading enzyme chlorophyllase (Parmar *et* al., 2013; Elloumi *et al*., 2014). Zouari *et al*., (2016) reported decreased Mg content in date palm leaves under Cd stress, and this element is require for chlorophyll synthesis (Cenkci *et al*., 2010), and the impairment of chlorophyll synthesis may be attributed to increase Reactive Oxygen Species (ROS) under heavy metals stress as they can induced chlorophyll alteration (Gomes *et al*., 2015). The obtained results showed that, the supply of Se simultaneously with Cd led to amelioration of chlorophyll content compared to Cd individual treatment; especially at high concentration of Se. Plants develop enzymatic and non-enzymatic systems to scavenge and avoid oxidative damage (Qing *et al*., 2015), Se improvement plant scavenging capability through activation antioxidant enzymes such as SOD and APX (Zembala *et* al., 2010; Wu *et al*., 2016) and non-enzymatic antioxidant such as α-tocopherol (Pedrero *et al*., 2008), and the increase in chlorophyll content in date palm leaves could be explained by the Se role in protection of chloroplast enzymes, consequently, increasing chlorophyll synthesis (Pennanen *et al*., 2002), the importance of Se in the regulation of uptake and distribution of some essential elements (e.g. Fe, Zn. Mn and Mg), with known role in enzymes activity as co-factorsand involved in pigments synthesis (Feng *et al.,* 2013).

Table (1) Chlorophyll content (mg.g^{-1} FW) in date palm plants treated with different concentrations of individual Cadmium or with Selenium

Treatment	Chla	Chlb	Total Chl
Control	4.20±0.04* a	1.33±0.08 a	5.53±0.07 a
Cd 3	3.39±0.06 c	1.26±0.01 ab	4.65±0.03 b
Cd 9	2.87±0.04 d	1.16±0.02 c	4.03±0.03 c
Cd 3 +Se 1	3.53±0.08 bc	1.29±0.01 ab	4.82±0.09 b
Cd 3 +Se 15	4.13±0.08 a	1.28±0.02 ab	5.41±0.09 a
Cd 9 +Se 1	2.89±0.11 d	1.15±0.02 c	4.04±0.12 c
Cd 9 +Se 15	3.70±0.20 b	1.24±0.02 b	4.94±0.07 b
LSD *(0.05)*	**0.24**	**0.07**	**0.37**

*Values represent the means of triplicates per treatment ± standard deviation.

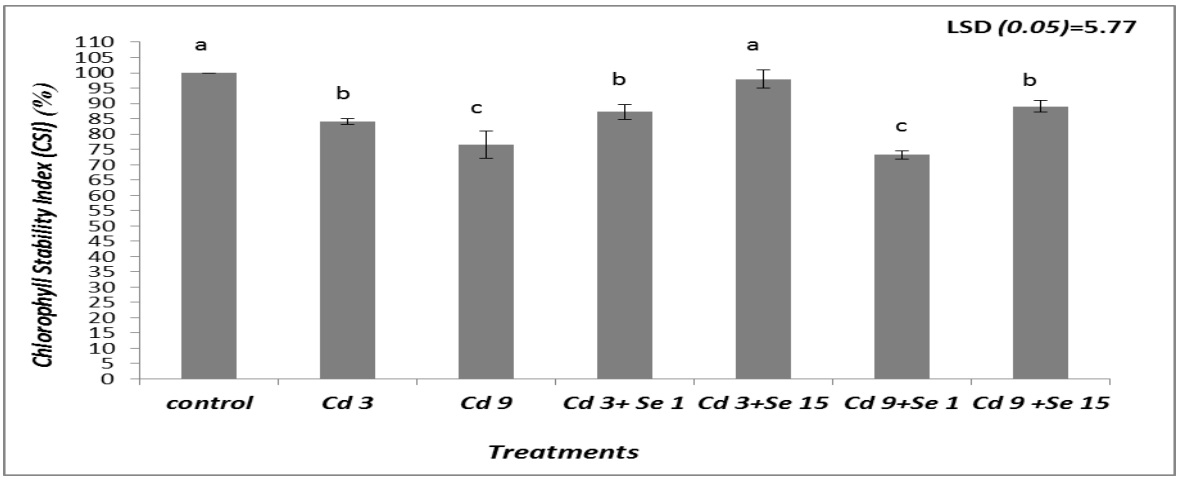

Fig (1) Chlorophyll Stability Index (CSI) (%) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

Lipid peroxidation and Membrane Stability Index (MSI)

Malondialdehyde (MDA) level in date palm leaves was measured as an indicator of extent lipid peroxidation, the results reveled that, the treatment with Cd at 3 and 9 mg.kg^{-1}alone resulted in a significant increase of MDA content compared with control treatment, which MDA content increased from 1.23 nmole.g^{-1} in control treatment to 2.20 and 3.30 nmole.g^{-1} in 3 and 9 Cd treatments respectively. The increase in MDA level was significant with increase Cd concentration (Fig 2). On other hand, Se treatment at 1 mg.kg^{-1}had no significant effect on MDA level when Se was added with Cd compared with individual Cd treatments at examined concentrations, while supplementation Se to soil at 15 mg.kg^{-1} led to significant decrease in MDA level compared to individual Cd treatments at 3 and 9 mg.kg^{-1}, which MDA decrease to 1.69 and 2.62 nmole.g^{-1}, when Se at 15 mg.kg^{-1} with Cd at 3 and 9 mg.kg^{-1} respectively.

Regarding membrane stability index (MSI), the results illustrated in Fig 3 showed that, the highest value of MSI was observed in untreated plants (80.82 %), while the lowest value was examined in plants treated with Cd at 9 mg.kg^{-1} without Se (60.51 %) and with Se at 1 mg.kg^{-1} (61.97 %).Obtained results showed that, the MDA accumulation increased by 62.72% in Cd treatment at 9 mg.kg^{-1}, and by 53.05% when added with Se at 15 mg.kg^{-1}, while the increase was 27.21% when Cd added at 3 mg.kg^{-1} with Se at 15 mg.kg^{-1}. MDA accumulation resulted from generation of ROS under Cd stress (Asgher *et al*., 2014). Theresult of this study is in consistent with Abass *et* al., (2016) and Zouari *et al.*, (2016) on date palm plants. In this study, Se supplementation reduced Cd induction of oxidative stress as reflected by reduced MDA accumulation, and that could be attributed to disturbance of ROS reaction chain by Se (Saidi *et al*., 2014; Qing *et al*., 2015), or through improving antioxidant enzymes activities (Wu *et al*., 2016). Filek *et al.* (2008) hypothesized that, Se compete with Cd for specific binding sites in envelope membrane proteins, such as thiol group in cysteine. Alleviation of Cd stress on MDA accumulation by Se has been reported in several studies (Zembala *et al*., 2010; Saidi *et al*., 2014; Wu *et al*., 2016).

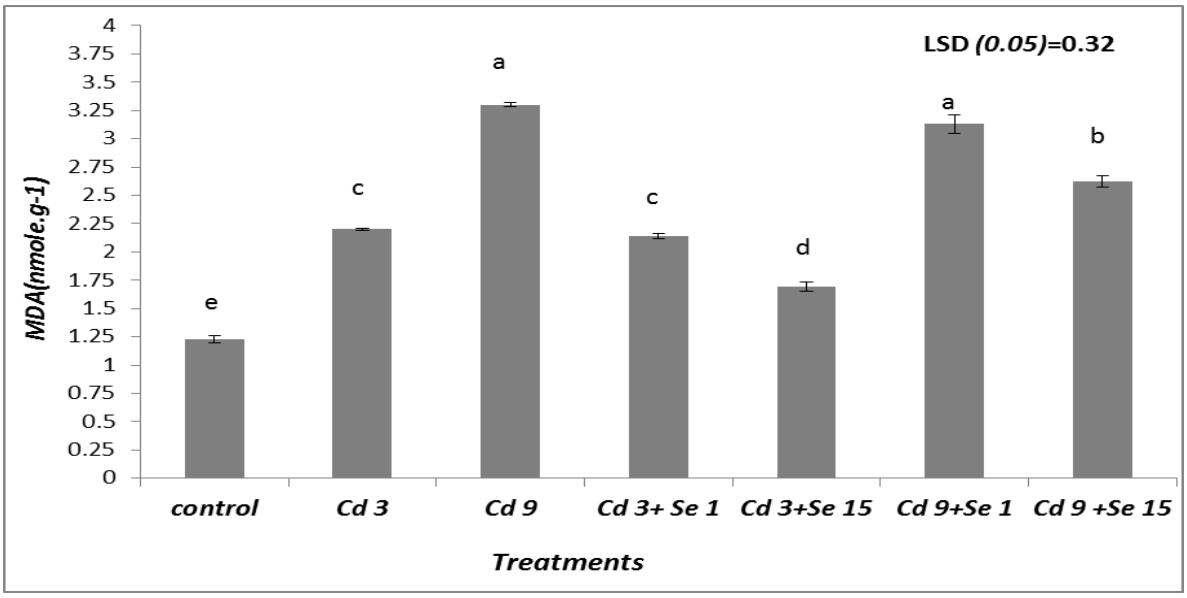

Fig (2) MDA (nmole.g^{-1}) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

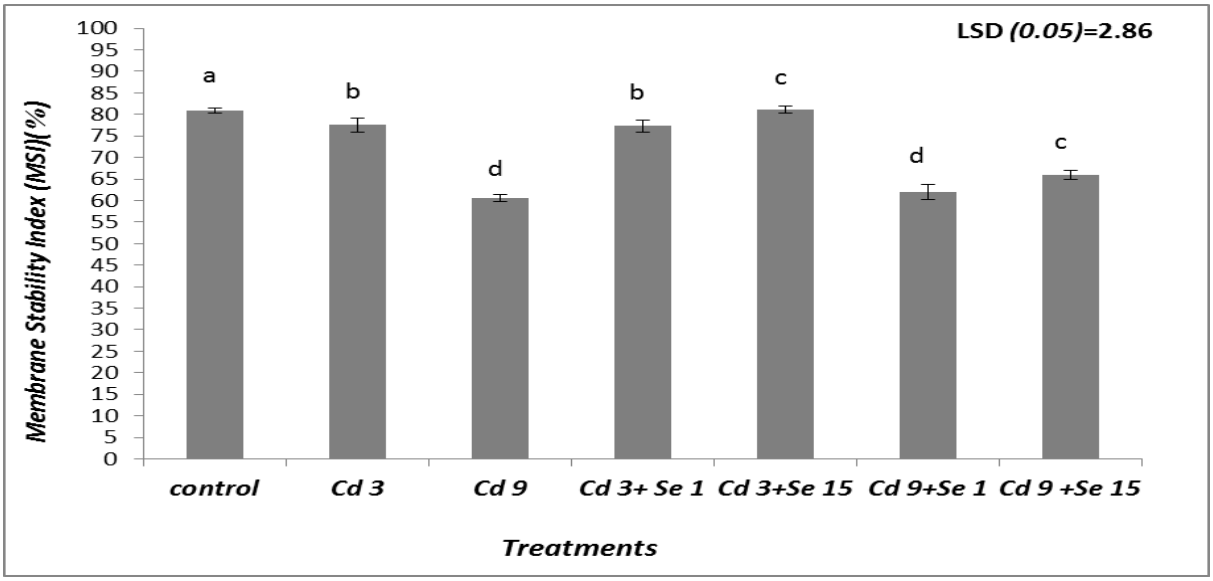

Fig (3) Membrane Stability Index (MSI) (%) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

Proline

Proline content in date palm plants leaves under different Cdconcentrations or with or Se were evaluated. Obtained results presented in Fig. 4 revealed that, proline content 2.75 µmole.g^{-1} in control plants, increased to 4.66 and 9.62 µmole.g^{-1} when Cd added at 3 and 9 mg.kg^{-1}, respectively. Se, on the other hand, didnot to affect proline content when added at 1 mg.kg^{-1}at each testing concentration of Cd, compared to Cd treatments alone at two concentrations. However, when Se added at 15 mg.kg^{-1} with Cd at 3 mg.kg^{-1} proline content did not change compared to control treatment, and decreased up to 6.42 µmole.g^{-1} when added with Cd at 9 mg.kg^{-1} compared to Cd at 9 mg.kg^{-1} treatment.As compared to

control plants, obtained results indicated to increase proline content in date palm leaves under Cd stress with or without Se, except when Se added at 15 mg.kg^{-1}with Cd at 3 mg.kg^{-1}. The increase in proline content reached to 71.41% and 71.53% when Cd at 9 mg.kg^{-1} added alone or with Se at 1 mg.kg^{-1} respectively, while reached to 57.16% when Cd at 9 mg.kg^{-1} added with Se at 15 mg.kg^{-1}.

Moreover, Cd at 3 mg.kg^{-1} increased proline content to 40.98% and 36.48%, when add alone or with Se at 1 mg.kg^{-1} concentration respectively.Proline accumulation is considered one of the plant adaptive strategies to heavy metals stress (Asgher *et al*., 2014; Khan *et al*., 2015; Abass, 2016). Proline act as agent in scavenging and controlling ROS (Singh *et al*., 2015), Also as metals chelating agent (Sharma *et al*., 1998). In the present study, Se application simultaneously with Cd led to decrease proline accumulation in date palm leaves compared to individual Cd treatments, the results of this study are in line with Shekari *et al*. (2017) findings on *Capsicum frutescence* L. plant. Huang *et al*., (2017) and Lin *et* al., (2012) reported that, Se reduced Cd accumulation, as well as, reduced root to shoot Cd translocation in *Oryza sativa* L. plants.

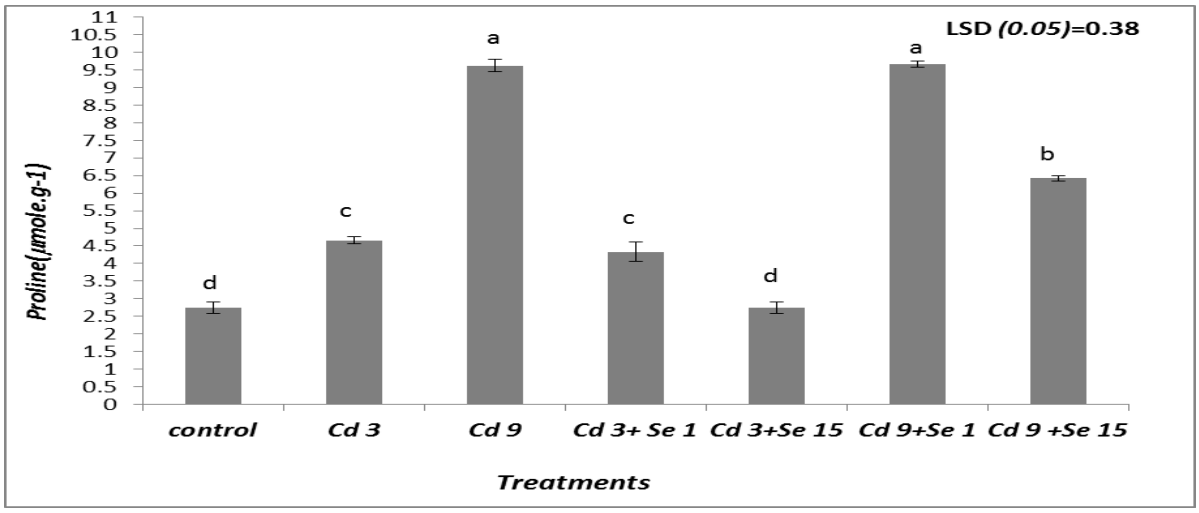

Fig (4) Proline content (µmole.g^{-1}) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

H_2O_2 and Peroxidase (POD) enzyme activity

Fig. 5 illustrated the response of date palm plants to Cd stress at presence or absence of Se. The results showed that, the highest level of H_2O_2 was recorded in date palm plants treated with individual Cd at 9 mg.kg^{-1} (2.86 µmole.g^{-1}) and Cd at same concentration with Se at 1 mg.kg^{-1} (2.84 µmole.g^{-1}), without any observed significant difference. However,the lowest level was observed in control plants group, which was 1.23 µmole.g^{-1}, with significant difference compared to other treatments. Additionally, results revealed that the supplementation of Se at 15 mg.kg^{-1} with Cd at 3 and 9 mg.kg^{-1} reduced H_2O_2accumulation significantly compared to added Cd at tested concentrations.

H_2O_2 increased about 32.41, 28.48 and 13.38% to alone Cd at 3 mg.kg^{-1} or with Se at 1 and 15 mg.kg^{-1} respectively. While the increase was up 56.99, 56.69 and 43.57% to alone Cd at 9 mg.kg^{-1} or with Se at 1 and 15 mg.kg^{-1}, respectively. Similar trends results observed with peroxidase (POD) activity, the highest activity of POD recorded in alone Cd at 9 mg.kg^{-1}

or with Se at 1 mg.kg^{-1} treatments, the enzyme activity was 41.78 and 41.20 unit/mint/g, respectively. The lowest enzyme activity was reported in control treatment (22.73 unit/min/g) without significant difference than Cd at 3 mg.kg^{-1} alone or with Se at 1 mg.kg^{-1}. In comparisonwith control plants, the increase about 20.52 and 45.59% when Cd added alone at 3 and 9 mg.kg^{-1} respectively, and about 20.66 and 8.45% when Cd added at 3 mg.kg^{-1} with Se at 1 and 15 mg.kg^{-1}, respectively, while the increase of POD activity was 44.83 and 36.93% when Cd added at 9 mg.kg^{-1} with Se at 1 and 15 mg.kg^{-1} respectively. The induce of H_2O_2 accumulation and POD activity under Cd stress are ina good agreement with Abass *et al*., (2016) and Zouari *et al*. (2016) findings on date palm plants. The presence of Se with Cd in soil led to reduce H_2O_2 accumulation in plant tissues compared to Cd stress,thus, reported in several studies with numerous plants such as*Brassica napus* (Filek *et al*.,2008) and *Helianthus annuus* (Saidi *et al*., 2014). The increase of H_2O_2 concentration in date palm leaves was accompanied with increase POD activity. Abass *et al*. (2016) suggest a vital role of POD enzymes in plant cells is their effective scavenging of H_2O_2. Reduction of H_2O_2 level in stresses plants, when supply by proper dose of Se, possibly due to activation of antioxidant mechanisms by Se, especially of H_2O_2 quenchers (e.g. GSH-Px) (Feng *et al*., 2013).

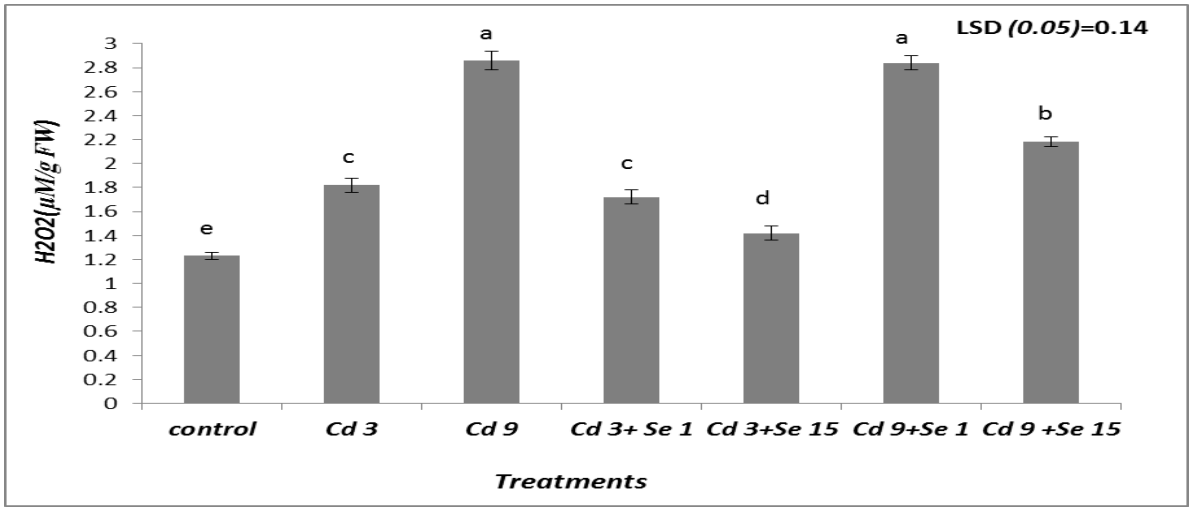

Fig (5) H_2O_2 content (µmole.g^{-1}) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

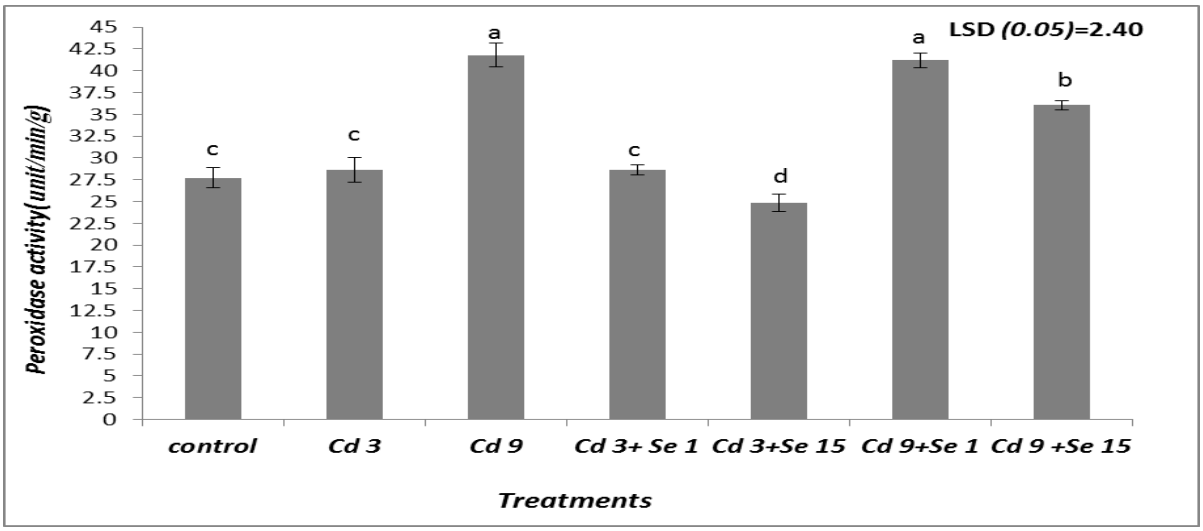

Fig (6) Peroxidase activity (U/m/g) in date palm plants treated with different concentrations of individual Cadmium or with Selenium.

Conclusion

The present study concluded that, Selenium at 1 mg/kg was not useful for plant to cope with cadmium stress, even at low concentrations of cadmium, while selenium at 15 mg/kg was very useful to alleviation cadmium toxicity at high and low concentrations. Se at 15 $mg.kg^{-1}$ reduced stress markers such as lipid peroxidation, H_2O_2 and peroxidase activity levels, when added with Cd compared to their levels under alone Cd stress, as well as enhance chlorophyll synthesis. Noteworthy, the appropriate concentration of Se for date palm still a needs further investigation.

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فعالية السيلينيوم في تخفيف سمية الكادميوم على نخيل التمر *Phoenix dactylifera* L.

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الخلاصة

أجريت هذه الدراسة لمعرفة تأثير السيلينيوم ودوره المحتمل في تخفيف سمية الكادميوم، اختيرت فسائل من نخيل التمر صنف الساير بعمر ثلاث سنوات مزروعة في سنادين وعرضت لمعاملات مفردة من الكادميوم بتركيزين (3 و 9 ملغم.كغم$^{-1}$) او مع السيلينيوم بتركيزين (1 و 15 ملغم.كغم$^{-1}$) في الوقت ذاته عن طريق مياه الري. أوضحت النتائج إن المعاملات المفردة من الكادميوم أدت إلى تراكم مركب Malondialdehyde (MDA) وبيروكسيد الهيدروجين والبرولين وزيادة فعالية انزيم البيروكسديز، وعلى العكس من ذلك أدت إلى تقليل محتوى الكلوروفيل ومؤشر ثباتية الكلوروفيل ومؤشر ثباتية الأغشية، سيما عند التركيز العالي من الكادميوم. بينما انخفض التأثير السام للكادميوم عندما أضيف مع السيلينيوم بتركيز 15 ملغم.كغم$^{-1}$ ، ولم يكن للسيلينيوم بتركيز 1 ملغم.كغم$^{-1}$ أي تأثير معنوي حتى مع التراكيز المنخفضة من الكادميوم. تراكم مركب MDAزاد بمعدل 62.72 و 53.05% وبيروكسيد الهيدروجين 56.99 و 43.57% والبرولين 71.35 و 57.16% وازدادت فعالية البيروكسيديز بمعدل 45.59 و 36.93 %، بينما انخفض محتوى الأوراق من كلوروفيل a الى 31.66 و 11.90% وكلوروفيلb 12.78 و 7.76% والكلوروفيل الكلي 23.32 و 10.66% ومؤشر ثبايتة الكلوروفيل الى 23.42 و 10.93% ومؤشر ثباتية الأغشية إلى 31.87 و 25.79% عند المعاملة المفردة للكادميوم بتركيز 9 ملغم.كغم$^{-1}$ ومعاملة الكادميوم بنفس التركيز مع السيلينيوم بتركيز 15 ملغم.كغم$^{-1}$ على التوالي، مقارنة بمعاملة السيطرة.

نتائج هذه الدراسة أظهرت إن إضافة السيلينيوم بالتركيز 15 ملغم.كغم$^{-1}$ أدت إلى تخفيف سمية الكادميوم على نخيل التمر.