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Change in nutritional value of mallow (*Malva parviflora* L.) under influence of selenium.

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The effect of selenium on *Malva parviflora* L. was examined. Mallow was reported for its nutritional value. Total proteins, total carbohydrates and mineral contents, macro elements and micro elements were estimated in roots, stems and leaves of *Malva parviflora* at different levels of selenium fertilization which treated in soil where the plant cultivated. The protein content of stems and roots were significantly increased with increasing in Se concentrations, also carbohydrate content of leaves, stems and roots were significantly increased with increasing in Se concentrations. The mineral content was also affected by Se concentrations, Fe, Cu and Zn of leaves decreased with increasing in Se concentrations, while K, Ca, Mg and Na were directly proportional with Se concentration. In stems, Zn only was decreased with increasing Se. In roots, Cu and Zn are inversely proportional while, Na, Ca, Mg and K were directly proportional with Se concentrations. The findings of this study revealed that carbohydrates, protein and mineral contents of mallow can be affected and controlled by selenium concentration.

Keywords: Mallow, selenium, carbohydrates, macro elements, micro elements.

INTRODUCTION

Since ancient times, plants played an important role in human nutrition, being a very important source of antioxidants, vitamins and minerals. Modern nutrition requires greater consumption of vegetables and fruits, because of their role in the quality of life (Elawa, 2015). Among vegetables, the leafy vegetables occupy an important position. The leafy vegetables are rich source of proteins, dietary fibers, pigments and vitamins which offer many functions for health benefits (Khan et al., 2015). *Mava parviflora L.* is an annual or perennial herb native to Northern Africa. Common names include cheese weed, mallow, Egyptian mallow and little mallow (Raheem et al., 2014). The genus Malva is a member of the family Malvaceae. *M. parviflora* is one of the most widespread species in Egypt and grows in different habitats from very moist to mid, which gives it different habits and sizes especially the leaf size. It is also cultivated on a small scale for its edible leaves (Boulos, 2000).*Malva parviflora* is a source of natural antioxidants and thus useful as a therapeutic agent in the slowing of aging and in the relief of age related and oxidative stress related degenerative diseases (Hussein et al., 2012). Malva (mallow) was derived from the greek malakos referring to its soft leaves or its medicinal attributes (Mitich, 1990 and Pippa et al., 2011). Chemical analyses of *M. parviflora* leaves showed that the plant is rich in protein, carbohydrates, soluble fibers, phenols, terpenoids, coumarins mucilage and pigments (Michael, 2006 and Messaoudi et al*.,* 2015). Additionally, its seeds contain significant amounts of antioxidants (Abousabaa, 2001). This plant was used in the conventional medicine in Africa and Eastern Europe in the skin disorders treatment (Abad et al., 2007). Scientific evidence indicated that different parts of *M. parviflora* due to therapeutic properties, are effective in the treatment of many gastrointestinal, dermatological, urological, haemorrhoidal, menstrual and vaginal disorders (Gasparetto et al., 2011). Traditionally, *M. parviflora* treat specified disorders of several systems of the body such as the digestive system, the respiratory, the genitourinary, and the muscular and skeletal systems as well as skin disorders and injuries (Barros et al., 2010 and Marouane et al., 2011). *M. parviflora*, shoot and root were characterized by the constitutive of proline, protein and carbohydrate contents (Salama et al., 2011). It was reported that this plant contains several important nutrients such as essential minerals, fatty acids and various terpene compounds with valuable biological properties. Furthermore, this vegetable possesses an important antioxidant activity and thus has the potential to be used as a cheap natural source for reducing cellular oxidative damage (Zouari et al., 2011).

Selenium is an important trace element for humans, animals and microorganisms for normal and healthy life (Zhu et al*.,* 2009). The presence of selenium in the medium for culturing higher plants is useful but not necessary. Excessive amounts of Se may be toxic to plants. The difference between the beneficial and toxic Se concentration in soil depends on the crop species (**Feng** et al., 2013). Selenium a metalloid mineral micronutrient becomes deficient (< 40 µg/day) and toxic levels (> 400 µg/day) (Fordyce, 2007). Low Se intake has been associated with a number of deficiency syndromes, particularly cardiomyopathy and osteoarthritis, recent research demonstrates the importance of Se to human health (Ellis and Salt, 2003). The aim of this study was to investigate the effect of selenium concentrations on macro and micro elements, total carbohydrates and total protein of *Malva parviflora L.* hence evaluate the selenium concentration on the food value of mallow that may considered this plant one of the more important foods of the future.

MATERIALS AND METHODS

Experimental design

There were 5 treatments including control and four different selenium treatments, Se was added to nutrient solution as sodium selenate (Na_2SeO_4) (3, 8, 15 &19 mg L^{-1}). These concentrations were selected according to previous studies (Wu, 2009). Each treatment was prepared in three replicates. Soil was collected at a depth of 0 to 20 cm from the field west Zagazig University, Egypt. Soil was air dried, allowed to pass through 5 mm sieve and put in pots the cultivated with mallow seeds during winter season (December 2016). Different concentrations of selenate spiked solutions were aspirated on to dry soil by a plastic nebulizer. After plant emerged and grew, plant samples were collected from each pot and separated into roots, stems and leaves for analyses.

2.2. Determination of mineral content

Samples were digested in 10 ml acids mixture (1 HNO3 + 3 HCl) according to (Prakash et al., 2011) and the elements in samples were measured by an atomic absorption and flame photometer Shimadzu Model AA640F (Japan).

2.3. Total carbohydrates content

Carbohydrates were estimated by phenol sulphuric acid method (Dubios et al., 1956) A known weight of dried plant samples for each treatment was extracted with 2.5 N HCl, hydrolyzed in boiling water bath for 3 hours and then cooled at room temperature. The solution was neutralized with sodium carbonate (Na_2CO_3) until the effervescence ceases then the volume was made up to 100 ml by distilled water and then centrifuged. One ml of 5% phenol solution and 5 ml of 96% H_2SO_4 were added to each tube and then shacked well. After 10 min, the contents in the tubes were placed in water bath at 25-30^{0}C for 20 min. The absorbance was read at 490 nm using spectrophotometer.

2.4. Total protein content

A known weight of fresh leaf, stem and root samples (0.5 g) was used for soluble protein analysis (Bradford, 1976). Soluble protein was extracted with 10 ml of a 25 mM borate buffer solution (pH 8.5) using a mortar and pestle on ice. 0.5ml of supernatant was added to 5 ml of protein reagent (Coomassie brilliant blue G250) and left for 5 min. The readings were done at 595 nm and the protein concentrations measured as mg g^{-1} dry weight. Using BSA (Bovine serum albumin) as standard.

2.5. Data analysis

Means and Standard Deviation (SD) values of variables were calculated. One-way ANOVA test were used according to (Steel et al., 1997).

RESULTS AND DISCUSSION

Plants readily absorb Se when it is in a soluble form, even though differences between plant species are commonly observed. The availability of soil with Se is also controlled by several soil factors, among which pH is believed to be the most pronounced factor (Kabata-Pendias, 2001). In general, it appears that Se is not required for plant growth, and that excessive Se values can be toxic (Dhillon and Dhillon, 2009; Broadley et al., 2006; White et al., 2004 and 2007). The ability of the plants to absorb Se, rate of their absorption and distribution to functional sites affect the normal and adequate nutrition of plants (Prakash et al., 2011).

The results revealed that Se can affect and control the carbohydrates, protein and mineral contents.

Micro nutrients

Plants vary in their sensitivities to concentration and chemical forms of Se in the soil (Karaj and Surjit, 2009). The results showed that micro nutrients Fe, Cu and Zn of mallow depend on the concentration of selenium added to soil. Fe, Cu & Zn in roots of mallow were inversely proportional with Se concentrations, where control had the highest mean values (0.087, 0.66, 0.82 respectively), while the lowest mean values were at 15and 19 mg L^{-1} of Se concentrations (Table 1). The micro elements Fe and Cu in stems were significantly increased with increasing Se concentrations. The highest mean values of Fe and Cu in stems at 15 and 19 mg L^{-1} Se concentrations were (0.006 and 0.127 respectively), but Zn was inversely proportional with Se levels, control had the highest mean value (0.22) while the lowest was (0.032) at 19 mg L^{-1} Se concentration (Table 2).

In leaves, control had the highest mean values of Fe and Zn were (0.031 and 0.26) while the lowest at 15 mg L^{-1} Se concentration were (0 and 0.076 respectively) but the highest value of Cu was at 19 mg L^{-1} Se concentration (0.171) and the lowest at 3 mg L^{-1} (0.137) (Table 3). The enrichment of soil with low concentrations of selenium was found to alleviate the negative impact of abiotic stressors such as salinity, UV radiation, drought and heavy metals on various plant species (Poldma et al., 2013). Abousabaa (2001) stated that *Malva parviflora* was found to be rich in Fe, Cu, Zn, P and Mn.

Macro nutrients

All macro nutrients in roots of mallow (K, Ca, Mg & Na) were directly proportional with Se concentrations, the highest mean values were at 8 mg L^{-1} (43.4, 45.49, 25.2 and 96.6 respectively) and control had the lowest mean values were (16.7, 34.09, 11.6 and 33.2 respectively) (Table 1).

In stems, K, Mg and Na were inversely proportional with Se concentrations, where control had the highest mean values were (54.53, 8.94 and 83.64 respectively) and the lowest at 15 mg L^{-1} Se concentration were (24.87, 7.05 and 68.09 respectively) while Ca only significantly increased with increasing Se concentrations, the lowest mean value in control was (29.94) while the highest mean value at 19 mg L^{-1} was (72.17) (Table 2). It was found that the ash content of mallow contains 2.11 mg/100g DM potassium, calcium (1.73 g g^{-100}DM) and magnesium (0.55g g^{-100} DM) as the most concentrated minerals (Nahed et al., 2016).

Macro elements (K, Ca, Mg & Na) in leaves of mallow as well as in roots increased with increasing in Se concentrations, control had the lowest mean values were (87.6, 103.5, 24.8 and 58.36 respectively) and the highest mean values were at 8 mg L^{-1} Se concentration (164.2, 365.7, 86 and 113.2 respectively) (Table 3).

Protein content

The protein content in roots as well as in stems of mallow was significantly increased by increasing in Se concentrations, control had the lowest values were (38.16 and 33.37 mg g^{-1} dry wt.) and the highest values were at 19 mg L^{-1} Se concentration, were (40.22 and 43.03 mg g^{-1} dry wt.) for roots and stems respectively. While the protein content in leaves decreased with increasing in Se concentrations, the highest amount in control was (39.13 mg g^{-1} dry wt.) (Table 4). Protein in leaves decreased with increasing in Se level, this may be due to disrupt the normal biochemical reactions and enzyme functions within the cells of leaves (Pezzarossa et al., 2007). At high concentrations, selenium replaces sulfur in amino acids, which produces nonfunctional proteins and enzymes (Terry et al., 2000).

Carbohydrates content

Plants readily absorb Se when it in soluble form. In general, it appears that growth rates of wheat plants depended on the concentration of selenium added to the soil (Balakhnina and Nadezhkina, 2017).

Table 1. Mean value and standard deviation of the elements in plant roots representing the different treatments of selenium

Se conc. (mg L^{-1})	Fe	Cu	Zn	K	Ca	Mg	Na
3	0.02+ 0.02	0.11+ 0.08	0.06+ 0.016	18.89+ 1.11	34.9+ 0.06	17.5+ 0.48	27.29+ 0.51
8	0.01+ 0.01	0.11+ 0.03	0.03+ 0.001	43.4+ 0.51	45.49+0.51	25.2+ 0.35	96.6+ 1.38
15	0.003+ 0.005	0.10+ 0.001	0.029+ 0.004	39.2+ 0.29	45.17+0.33	13.6+ 0.31	58.8+ 0.211
19	0.007+ 0.006	0.17+ 0.006	0.028+ 0.011	26.12+ 0.88	39.6+ 0.34	20.3+ 0.65	49.3+ 0.42
0	0.08+ 0.042	0.66+ 0.06	0.82+ 0.29	16.7+ 1.25	34.09+ 0.91	11.6+ 0.63	33.2+ 0.72
F-test	*	***	***	***	***	***	***
P-value	0.046	000	000	000	000	000	000
L.S.D	0.073	0.045	0.147	1.124	0.993	0.771	1.10

*significant, $P<0.05$; **significant, $P<0.01$; ***significant, $P<0.001$

Table 2. Mean value and standard deviation of the elements in plant stems representing the different treatments of selenium

Se conc. (mg L^{-1})	Fe	Cu	Zn	K	Ca	Mg	Na
3	0.01+ 0.17	0.09+ 0.007	0.033+0.008	27.03+1.97	39.43+ 1.43	8.5+ 0.50	68.09+ 0.91
8	0.01+ 0.017	0.118+0.003	0.047+ 0.01	37.14+ 1.86	60.41+ 0.60	7.15+ 0.65	54.39+ 1.61
15	0.006+0.005	0.120+ 0.01	0.033+ 0.01	24.87+ 1.13	38.21+ 0.21	7.05+ 0.25	31.86+ 1.14
19	0.003+0.005	0.127+0.017	0.032+0.021	29.31+ 1.69	72.17+ 1.17	7.22+ 0.38	47.82+ 1.18
0	0.01+ 0.005	0.10+ 0.001	0.22+0.28	54.53+ 1.47	29.94+ 5.81	8.94+ 0.53	83.64+ 1.36
F-test	Ns	Ns	Ns	***	***	***	***
P-value	0.67	0.45	0.29	000	000	000	000
L.S.D	0.013	0.039	0.120	2.47	3.20	0.85	0.49

Ns, nonsignificant

Table 3. Mean value and standard deviation of the elements in plant leaves representing the different treatments of selenium

Se conc. (mg L^{-1})	Fe	Cu	Zn	K	Ca	Mg	Na
3	0.01+ 0	0.137+0.013	0.080+0.013	134.43+1.57	327.65+0.35	27.68+1.81	63.55+1.45
8	0.02+0.007	0.155+0.023	0.089+ 0.01	164.25+1.75	365.74+1.26	86+ 2	113.26+1.74
15	0+ 0	0.150+0.017	0.076+0.019	74.12+ 1.88	220.4+ 1.52	47.89+0.11	70.07+ 1.93
19	0.01+0.017	0.171+0.021	0.099+0.011	136.12+1.88	136.12+2.12	42.11+1.89	82.15+ 1.85
0	0.031+0.009	0.153+ 0.04	0.26+ 0.28	87.40+ 1.22	103.5+ 1.49	24.8+ 2.69	58.93+ 1.03
F-test	**	Ns	Ns	***	***	***	***
P-value	0.007	0.177	0.58	000	000	000	000
L.S.D	0.013	0.032	0.12	0.87	4.24	1.95	1.13

Table 4. Amount of total protein and total carbohydrate (mg g^{-1} dry wt.) in Leaves, Stems and roots of *Malva parviflora*

Se conc. (mg L^{-1})	Leaves		Stems		Roots	
	Protein	Carbohydrate	Protein	Carbohydrate	Protein	Carbohydrate
3	38.65	25	33.37	14.87	38.30	11.97
8	37.90	29	37.71	17.5	38.16	21.3
15	37.94	25	39.21	16.8	39.85	24.2
19	37.90	30.88	43.03	19.3	40.22	24.4
0	39.13	17.2	37.67	14.2	38.16	12.3
Mean	38.30	25.41	38.19	16.53	38.93	18.83
S.D.	0.561	5.25	3.47	2.05	1.01	6.23
S.E.	0.251	2.35	1.55	0.918	0.452	2.78

Carbohydrates in roots, stems and leaves of mallow were significantly increased with increasing in Se concentrations, the highest values were at 19 mg L^{-1} Se concentration (24.4, 19.3 and 30.88 mg g^{-1} dry wt. respectively). Control had the lowest values were (12.3, 14.2 and 17.2 mg g^{-1} dry wt. respectively) (Table 4).

Studies by (Pennanen et al., 2002) indicated that plant growth promoted by Se is the result of increased starch accumulation in chloroplasts. It was shown that Se has also positive effects on potato carbohydrates accumulation (Turakainen et al., 2004). At highest Se addition (0.3 mg kg^{-1}), the highest soluble sugar concentration was observed in the upper leaves 4 weeks after planting (from cca 75 to cca 90 mg g^{-1} dry wt.) and in roots (from cca 25 to cca 50 mg g^{-1} dry wt.) and stolons (from cca 150 to cca 175 mg g^{-1} dry wt.) at maturity.

CONCLUSION

Carbohydrates of leaves, stems and roots of mallow were increased with increasing in Se concentration as in protein of roots and stems while, protein of leaves decrease with increasing in Se concentrations. The mineral content was also affected by Se concentration, Fe and Cu of roots and leaves were decreased with increasing in Se concentrations while of stems increase with increasing Se levels. K, Ca, Mg and Na of roots as well as of stems are inversely proportional with Se levels while, these macroelements of leaves increase with increasing of Se concentrations.

The results revealed that selenium had clear effect on the level of carbohydrates and proteins in all parts of the plant as well as on macro and micronutrients.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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AUTHOR CONTRIBUTIONS

KHF, HM: are supervisors of PhD thesis of SHA, wrote and revised the manuscript; SHA: experimental work; KHF, HM: statistical analysis, figures and wrote the first draft. All authors read and approved the final manuscript.

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