Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 13, (2024)
https://www.jneonatalsurg.com

OPEN ACCESS

Effect of nano selenium or nano silicon on antioxidants activity and leaf anatomy of lavender plant under salinity stress conditions

Aya G. Ahmed [1], Mahmoud M. Khalil [1], Darwish M. Ebrahim [1] Ahmed Sh. Gendy [2], Sabah G.El-Banna [3], Mohamed S.Boghdady [4]

[1]Plant Production Dept.,Fac.of Technol. and Develop., Zagazig University, Egypt
Email ID : aghareb3@yahoo.com , Mahmoud.m.Khalil@hotmail.com , dr_darwish_47@yahoo.com

[2]Horticulture Dept.,Fac.of Agriculture , Zagazig University, Egypt
Email ID : shaker8873@gmail.com

[3]Environmental Studies Dept., Institute of Graduate studies and Researches , Alexandria University.
Email ID : igsr.sabah_gaber@alexu.edu.eg

[4]Botany Dept., Fac. of Agriculture , Zagazig University, Egypt
Email ID : Hdeeby03@gmail.com

Corresponding author –
Aya Gharib Ahmad Ahmad Ismail Deeb

Cite this paper as Aya G. Ahmed , Mahmoud M. Khalil , Darwish M. Ebrahim , Ahmed Sh. Gendy , Sabah G.El-Banna, Mohamed S.Boghdady (2024) Effect of nano selenium or nano silicon on antioxidants activity and leaf anatomy of lavender plant under salinity stress conditions.Journal of Neonatal Surgery, 13, 1754-1765

ABSTRACT

This study was conducted at the Nursery of ornamental plants, Hort. Depart., Faculty of agricultural., Zagazig Univ., and at Hormmone Laboratory, Department of Environmental Studies, Institute of Graduate Studies & Research- Alexandria University Egypt, during two consecutive seasons of 2023 and 2024 to evaluate the effect of foliar application of biological selenium and silicon nanoparticles under water salinity conditions on antioxidants activity and leaf anatomy of lavender plant. The tested saline water was at four levels (control(157), 1000, 1500, 2000 ppm). While, examined foliar spraying with nano-particles were seven concentrations viz, (control, 100, 200 and 300 ppm) nano- selenium and (100, 200 and 300 ppm) nano- silicon . The achieved results of this study showed that the foliar spray with nano-selenium or nano- silicon decreased thiobarbituric acid reactive substances and DNA breakages (%), plants sprayed with 300 ppm nano- selenium or 300 ppm nano-silicon increased amount of catalase activity in leaves. Plants treated with nano- selenium at level 200 ppm induced a prominent increase in medvein and lamina thickness by 15.8 and 8.4 % respectively compared to control (14.4, 16.7%). Plants treated with silicon at level 200 ppm increased medvein thickness by 14.3 %, while lamina thickness decreased by 17.7%..

Keywords: *salinity- nano selenium- nano silicon- antioxidants activity – leaf anatomy- lavender plant*

1. INTRODUCTION

Lavender plants are widely utilized in essential oil industry. Bulgaria, France, UK, China, Ukraine, Spain, and Morocco are the biggest worldwide producers. Bulgaria has recently become the world's major producer with 100 tons' lavender oil per year **(Vasileva *et al*.,2018).**

Changes in climatic conditions lead to increased biotic and abiotic stress on plants. The productivity of aromatic plants was affected globally due to these stresses **(Mahajan *et al.*, 2020).** Salt stress is a significant challenge for aromatic plants and can have various negative effects on their growth and productivity. One of the primary impacts of salt stress is a decrease in osmotic potential, leading to reduced availability of water for plants. This can result in water stress and reduce plant growth. In addition to water stress, salt stress also affects the physical structure of soil. It diminishes water permeability and soil aeration, further hindering plant growth **(Stefanakis *et al*.,2024).**

Nanotechnology has emerged as a useful strategy for improving agricultural productivity due to rapid and complete absorption of Nano-fertilizers by plants **(Sajyan *et al*., 2020**).

Selenium reduces the effects of climate change-related stresses such as drought, salinity, heavy metals, and metalloid stress through the glutathione peroxidase

(GSH) pathway, seleno proteins function as potent antioxidants in plant metabolism. They also increase the activity of compounds involved in the scavenging of ROS and cell detoxification, such as ascorbic acid, flavonoids, and tocopherols. Accurate dosages of Se can repair damaged cell structures and functions and stimulate photosynthesis. Thus, it combats a variety of abiotic and biotic stresses by regulating antioxidant systems and metabolism and rebalancing vital components in plant tissues **(Feng *et al.* 2013).** Selenium plays a critical role in tolerance against some environmental stress, like acting as an antioxidant and reducing oxidative stress and enhancing plant growth **(Mozafariyan *et al.*, 2016).**

The purpose of this study was to evaluate the effect of Se-NPs or Si-NPs on antioxidants activity and leaf anatomy of lavender plant under salinity stress conditions.

2. MATERIALS AND METHODS

This investigation was carried out at the Nursery of ornamental plants, Hort. Depart., Faculty of Agricultural., Zagazig Univ., Egypt and at Hormmone Laboratory, Department of Environmental Studies, Institute of Graduate Studies & Research-Alexandria University., Egypt during two consecutive seasons of 2023 and 2024 to evaluate the effect of foliar application of biological selenium or biological silicon nanoparticles under water salinity conditions on antioxidants activity and leaf anatomy of *Lavandula officinalis* Chaix (lavender) plant.

This study was designed as factorial experiment between the saline water levels and nano selenium or nano silicon in completely randomized block design.

The first factor (main plot) studied four water salinity levels viz., tap water(157ppm), 1000, 1500,2000 ppm NaCl.

The second factor (sub plot) studied seven concentrations of biological nano -selenium viz., control, 100, 200, 300 ppm or nano-silicon viz., (100,200, 300 ppm).

2.1.Plant material and cultivation

Lavandula officinalis (lavender) plants were planted in 25 cm pots filled with soil mixture of clay and sand (1:2 *v/v*), on March 1st during 1st and 2nd seasons (2023 and 2024). All plants were similar in growth (12 cm height with 8-10 leaves / plant). Forty days after planting, plants were treated with four different levels of saline water by using drip irrigation and sprayed with nano selenium or nano silicon every 15 days with the above mentioned concentrations . To avoid osmotic shock, the salinity treatment started with 500 ppm NaCl and was progressively increased to reach the maximum salinity level in each treatment.

The physical and chemical properties of soil analysis mixture as shown in **Table 1** according to **Evenhuis and Waard (1980).**

Table 1. Physical and chemical properties of experimental soil

Physical analysis												**Soil texture**
Clay (%)	**Silt (%)**		**Sand (%)**	**Organic material (%)**								**Sandy**
22.37	7.93		69.70	1.12								
Chemical analysis												
pH	**E.C. (dsm^{-1})**	**Soluble cations (meq/L)**				**Soluble anions (meq/L)**				**Available (mg/kg)**		
		Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	CO_3^{-}	N	P	K
8.22	8.13	13.78	10.75	30.45	0.24	51.02	2.46	38.74	0.05	29.54	9.23	100.1

Table 2. Chemical analysis of salt (water-salt extract at 5:1)

E.C. (mmhos/cm)	Soluble cations (m.mol/L)				Soluble anions (m.mol/L)			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	CO_3^{-}
171.3	9.28	8.54	3000	2.80	2935	4.86	80.76	0.0

2.2. Data Recorded:

2.2.1Determination of antioxidant enzymes activity Enzyme extraction

After 130 days from planting leaves were taken to estimate the enzymes contents according to **Mukherjee and Choudhuri (1983)**.

2.2.1.1. Assay of thiobarbituric acid reactive substances (TBARS) in *lavandula officinalis* plant were measured as described by **Tappel and Zalkin (1959)**.

2.2.1.2. Determination of reduced glutathione (GSH) was determined according to the method described by **Ellman (1959).**

2.2.1.3. Determination of catalase activity was determined according to the method described by **Sinha (1972).**

2.2.1.4. Determination of superoxide dismutase (SOD) activity was assayed in plant tissue extracts according to the method described by (**Nishikimi *et al*. 1972)**.

2.2.1.5. Assay of cytochrome b5 and cytochrome P450 were estimated according to **Omura and Sato (1964).**

2.2.1.6. Assay of the activity of amidopyrine N-demethylase was measured according to **Nash (1953).**

2.2.1.7. Assay of aniline 4-hydroxylase activitywas measured according to **Kato and Gillette (1965).**

2.2.1.8. DNA breakages% assay was measured according to **Wu *et al*. (2006).**

2.2.2. Anatomical studies

A comparative microscopical examination was performed on plant material for treatment which showed remarkable response. In addition to the control, the sample was taken from the blade of the growing leaves on the first basal branch of the lavender plant. Specimens were taken throughout the second growing season of 2024 after 70 days from planting date. Specimens from control and chosen treatment, including stems and leaves, were killed and fixed for at least 48 hrs. in F.A.A. (10 mL formalin, 5 mL glacial acetic acid and 85 mL ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56°C, sectioned to a thickness of 20 micrometer (m), double stained with safranin and fast green, cleared in xylene and mounted in Canada balsam **(Nassar and El-Sahhar, 1998) .** Sections were examined to detect histological manifestations of the chosen treatments and photomicrography made.

2.3. Statistical Analysis

The collected data were statistically analyzed according to **Steel and Torrie (1980)**. Mean separation was done using Duncan's multiple range test at 5 % level (**Duncan, 1955**). All achieved data were analyzed using IBM SPSS Software **(SPSS, 2020)**.

3. RESULTS AND DISCUSSION

3.1. Effect of interaction between nano selenium or nano silicon with water salinity on oxidative stress markers during 2024 season

3.1.1. Thiobarbituric acid reactive substances (TBARS), DNA breakage %, Enzymatic antioxidant (catalase, superoxide dismutase activity) and non-enzymatic antioxidant (reduced glutathione)

Data presented in Tables 3,4,5,6,and 7 shows that saline water with 2000 ppm significantly increased oxidative stress (Thiobarbituric acid reactive substances **(**TBARS) ,DNA breakages percentage and decreased catalase(CAT), superoxide dismutase(SOD) activity and Glutathione (GSH) . Due to their very high reactive nature, ROS generated various damages to molecules and cellular structures, including DNA, proteins, lipids, and cell membranes (**Sachdev *et al*., 2021)**. Salt stress causes changes in gene expression in the majority of plants, resulting in increased synthesis of osmoregulators and osmoprotectors **(Abo-Kassem, 2006)**.

Ghasemian *et al.* (2021) evaluated the impact of four salinity levels (0, 50, 100, and150 mM NaCl) on superoxide dismutase

(SOD) activity of *Melissa officinalis*. They found that the SOD activity increased from control to 150 mM NaCl. Also, the result was almost the same for catalase activity compared with the control.

Salt stress is abiotic stress lead to damage plant cells direct or indirect by forming reactive oxygen species (ROS). SOD reduced ROS production, thus reducing cell oxidation, these results are in agreement with **Soliman *et al.* (2015)**.

The reduction in GSH in this study may be due to the main oxidation under salinity stress conditions and it is essential for increasing the stress protectant antioxidant GSH.

Tables 3,4,5,6,and 7 shows effect of foliar spray with nano-selenium and nano- silicon significantly decreased oxidative stress as thiobarbituric acid reactive substances and DNA breakages (%). The lowest values of TBARS were at 300 ppm nano selenium but the lowest values of DNA breakage % were at 300 ppm nano silicon.

Similarly, in a hydroponic experiment with *Setaria italica*, the activities of SOD, CAT and GST were increased by the addition of 50 and 200 mM NaCl. However, the exogenously applied of 1 µM selenite (Na_2SeO_3) to the medium significantly improved the activities of these enzymes and improved the ant oxidative defense system **(Shah *et al* .,2020)**.

Gonzalez-García *et al.* (2021) revealed that Se–NPs (10 and 50 mg L^{-1}) alleviated the destructive effect of salinity (25 and 50 mM NaCl) on bell pepper (*Capsicum annuum*), variety "Kitrino" by increased CAT and GSH activity.

Table 3. Effect of interaction between nano selenium or nano silicon with water salinity on thiobarbituric acid reactive substances nmole/g (TBARS) of lavender plant (average of both seasons)

Water salTBARS) of-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	4.723 f	5.029 e	3.853 i	5.044 e	**4.662 B**
100 Se	3.923 i	3.131 j	2.847 k	4.051 hi	**3.488 E**
200 Se	5.172 e	2.715 kl	2.617 lm	3.090 j	**3.398 E**
300 Se	4.236 gh	2.520 lm	2.479 mn	2.310 n	**2.886 F**
100 Si	4.272 g	6.105 b	5.869 c	8.131 a	**6.094 A**
200 Si	3.192 j	5.061 e	3.859 i	5.579 d	**4.423 C**
300 Si	2.567 lm	3.219 j	4.304 g	4.559 f	**3.662 D**
Mean	**4.012 B**	**3.969 B**	**3.690 C**	**4.681 A**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 4. Effect of Nano selenium and Nano silicon on DNA breakages (%) of lavender plant under salinity stress conditions (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	7.078 ij	16.120 b	17.780 a	17.840 a	**14.705 A**
100 Se	6.084 k	11.040 d	9.060 f	14.400 c	**10.146 B**
200 Se	6.920 j	7.920 h	7.780 h	9.920 e	**8.135 C**
300 Se	2.720 mn	6.840 j	7.360 i	8.600 g	**6.380 D**
100 Si	0.515 q	1.738 o	2.361 n	6.684 j	**2.825 E**
200 Si	0.671 pq	0.927 p	1.407 o	4.471 l	**1.869 F**
300 Si	0.528 pq	0.871 pq	1.404 o	2.950 m	**1.438 G**
Mean	**3.502 D**	**6.494 C**	**6.736 B**	**9.266 A**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 5. Effect of Nano selenium and Nano silicon on Catalase activity (IU/g tissue) of lavender plant under salinity stress conditions (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	1.197 a	0.994 b	0.603 i	0.403 lm	**0.799 A**
100 Se	0.668 gh	0.534 j	0.603 i	0.451 k	**0.564 E**
200 Se	0.773e	0.727 f	0.791 e	0.376 m	**0.667 C**
300 Se	0.860 c	0.811 de	0.840 cd	0.443 kl	**0.739 B**
100 Si	0.725 f	0.776 e	0.723 f	0.424 kl	**0.662 C**
200 Si	0.528 j	0.807 de	0.551 j	0.619 i	**0.626 D**
300 Si	0.838 cd	0.839 cd	0.713 fg	0.629 hi	**0.755 B**
Mean	**0.798 A**	**0.784 A**	**0.689 B**	**0.478 C**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 6. Effect of Nano selenium and Nano silicon on Superoxide dismutase activity (SOD) IU/g tissue of lavender plant under salinity stress conditions (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	1471.13 bc	1462.50 efg	1452.84 h	1366.51 k	**1438.25 D**
100 Se	1460.99 g	1463.94 efg	1464.27 efg	1464.14 efg	**1463.33 B**
200 Se	1453.41 h	1438.76 j	1471.34 bc	1463.68 efg	**1456.80 C**
300 Se	1481.63 a	1462.25 efg	1473.56 b	1452.94 h	**1467.60 A**
100 Si	1470.86 bcd	1466.86 cde	1461.56 fg	1474.80 b	**1468.52 A**
200 Si	1444.79 i	1466.06 def	1462.50 efg	1472.81 b	**1461.54 B**
300 Si	1452.63 h	1464.00 efg	1459.75 g	1473.38 b	**1462.44 B**
Mean	**1462.20 AB**	**1460.63 B**	**1463.69 A**	**1452.61 C**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 7. Effect of Nano selenium and Nano silicon on Reduced glutathione (GSH) mg/g tissue of lavender plant under salinity stress conditions (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	32.376 a	14.192 c	1.653 lm	2.213 kl	**12.609 A**
100 Se	21.304 b	2.739 jk	1.727 lm	1.340 mn	**6.778 B**
200 Se	9.786 d	3.546 hij	4.559 fg	1.173 mn	**4.766 D**
300 Se	7.266 e	4.426 fg	7.019 e	3.813 ghi	**5.631 C**
100 Si	5.120 f	5.173 f	1.420 lmn	3.880 ghi	**3.898 E**
200 Si	3.863 ghi	4.093 gh	0.913 mn	0.740 n	**2.402 F**
300 Si	3.100 ji	3.168 ij	0.633 n	0.787 n	**1.922 G**
Mean	**11.831 A**	**5.334 B**	**2.561 C**	**1.992 D**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 8. Effect of Nano selenium and Nano silicon on Glutathione-S-transferase (GST) IU/g tissue of lavender plant under salinity stress conditions (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	3.920 de	4.139 cde	4.976 ab	5.212 a	**4.562 A**
100 Se	4.605 bc	3.738 efg	2.885 ijk	3.959 de	**3.797 BC**
200 Se	4.009 de	2.428 kl	3.311 ghi	2.248 l	**2.999 E**
300 Se	4.595 bc	4.409 cd	3.776 efg	3.092 ij	**3.968 B**
100 Si	3.709 efgh	5.300 a	3.881 e	5.138 a	**4.507 A**
200 Si	3.121 ij	4.119 cde	2.692 jkl	3.359 fghi	**3.323 D**
300 Si	3.197 hij	3.945 de	3.171 ij	3.848 ef	**3.540 CD**
Mean	**3.879 A**	**4.011 A**	**3.527 B**	**3.837 A**	

Treatments within Se-NPs, Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

3.1.2. cytochrome b5, Cytochrome P450 (CYPs) activity

Data in Tables 9,10 shows that irrigation by saline water at 2000 ppm increased cytochrome P450 content in leaves compared to other salinity levels. Also saline water level at 1500 ppm significantly increased cytochrome b5 content.

In this study, salt stress causes the generation of oxygen radicals, which leads to increase lipid oxidation and oxidative stress in plants.

plants sprayed with 300 ppm nano- selenium increased cytochrome b5 activity in leaves compared to control plants . Also, Cytochrome P450 increased by foliar spraying nano selenium at 200 ppm compared to nano silicon at 300 ppm .

Plants have developed numerous methods to survive in highly salinized soil. It has also been demonstrated that CYP proteins are crucial in plant responses to salt stress by regulating hormone signaling and maintaining ROS homeostasis **(Wang *et al.*,2020).**

CYPs play a pivotal role in a wide range of cellular functions that profoundly impact plant growth and development. CYPs synthesize secondary metabolites, including terpenoids, flavonoids, steroids, alkaloids, phenylpropanoids, glucosinolate, and cyanogenic glycosides. Plant CYP is critical in numerous metabolic processes and can bind to various biological compounds. As a result of these reactions, different fatty acid conjugates, plant hormones, secondary metabolites, lignin, and many protective chemicals are produced **(Tang *et al.*,2016)**

Table 9. Effect of Nano selenium and nano silicon on cytochrome b5 nmole cytochrome/ mg protein (mg/g) of lavender plant under salinity stress condition (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	0.203 l	0.305 ij	0.736 a	0.517 cd	**0.440 B**
100 Se	0.341 h	0.420 fg	0.749 a	0.407 g	**0.479 A**
200 Se	0.444 ef	0.607 b	0.282 j	0.400 g	**0.433 B**
300 Se	0.463 e	0.444 ef	0.521 cd	0.458 e	**0.472 A**
100 Si	0.419 fg	0.504 d	0.241 k	0.238 k	**0.350 D**
200 Si	0.540 c	0.305 ij	0.459 e	0.237 k	**0.385 C**
300 Si	0.591 b	0.141 m	0.215 kl	0.317 hi	**0.316 E**
Mean	**0.429 B**	**0.390 C**	**0.458 A**	**0.368 D**	

Treatments within Se-NPs , Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

Table 10. Effect of nano selenium on Cytochrome P450 nmole cytochrome/ mg protein (mg/g) of lavender plant under salinity stress condition (average of both seasons)

Water salinity / Nano-Se or Nano Si (ppm)	Tap water	1000ppm	1500ppm	2000ppm	mean
control	0.367 q	0.842 k	1.490 c	1.176 de	**0.969 C**
100 Se	0.671 lm	1.194 d	0.850 jk	2.903 b	**1.405 A**
200 Se	0.917 ijk	1.197 d	0.474 opq	3.170 a	**1.440 A**
300 Se	0.957 hij	1.042 fgh	1.079 efg	1.116 def	**1.049 B**
100 Si	1.078 efg	1.001 ghi	0.459 pq	0.606 lmn	**0.786 D**
200 Si	0.703 l	0.577 mno	0.830 k	0.440 pq	**0.637 E**
300 Si	1.161 de	0.439 pq	0.545 nop	0.587 mn	**0.683 E**
Mean	**0.836 C**	**0.899 B**	**0.818 C**	**1.428 A**	

Treatments within Se-NPs , Si- NPs column and salinity levels followed by different letters are significantly different with Duncan's multiple range test at 5 % level.

3.2. Effect of interaction between nano selenium or nano silicon with water salinity on leaf anatomy during 2024 season

3.2.1. Effect of salinity (2000 ppm), selenium (200 ppm) and silicon (200 ppm) on leaf anatomy of *Lavandula officinalis* chaix.

Measurements of certain characters in transverse sections through the blade of growing leaves on the first basal branch of ***Lavandula officinalis*** **plants** and those grown under **salinity (2000 ppm) , selenium (200 ppm) and silicon (200 ppm)**, after 70 days from planting date are presented in **Table** 11 **and Figure 1**.

It is realized that salinity is at level 2000 ppm. decreased the thickness of both midvein and lamina by 23.7 and 27.7% less than those of control plants, respectively. The decrease in lamina could be attributed to the reduction in thickness of mesophyll tissues. The decrements below the control were 30.0 and 34.8 % for the thickness of palisade and spongy tissues, respectively. Upper epidermis and lower epidermis were unaffected. Such treatment decreased dimensions of medvein bundles below the control by 20.0 % in length and by 20.0 in width. Number of vessels/medvein bundles decreased less than the control by 25.0 %. Moreover, the mean diameter of vessels reduced by 45.4 % less than the control.

Plants treated with selenium **at** level 200 ppm induced a prominent increase in medvein and lamina thickness by 15.8 and 8.4 %, respectively. The increase in lamina thickness which was observed could be attributed mainly to the increase in thickness of upper epidermis and, thickness of palisade. The increments over those of control plants were 14.4, 16.7%; respectively. Lower epidermis and spongy tissues were unaffected. Also, the medvein bundle showed a prominent increase in width by 46.6%, while the length decreased by by 4.3%. The number of vessels/medvein bundle increased over the control by 25.0 % .Diameter vessels showed an increased by 9.4 % compared with control plants.

Plants treated with nano- silicon **at** level 200 ppm induced increase in medvein thickness by 14.3 %, while lamina thickness decreased by 17.7%. The decreased in lamina thickness which was observed could be attributed mainly to the decreased in thickness of upper epidermis and thickness of spongy tissues. The reduction below those of control plants were 42.7, 34.8%; respectively. Palisade tissues increase by 7.8%. Lower epidermises are not affected. The medvein bundle showed a prominent increase in width of 11.6%, and length by 13.3%. The number of vessels/medvein bundles increased over the control by 50.0 %. The vessels' diameter is not affected.

4.3.2.5.2. Effect of interaction between salinity (2000 ppm) X selenium (200 ppm) and salinity (2000 ppm) X silicon (200 ppm) on leaf anatomy of lavender plant:

Measurements of certain characters in transverse sections through the blade of the growing leaves on the first basal branch of ***Lavandula officinalis*** plants and those grown under **salinity (2000ppm) X selenium (200 ppm) and salinity (2000 ppm) X silicon (200 ppm)**, after 70 days from planting date, are presented in (**Table 11**) and **(Figure 1).**

It is realized that Plants treated with selenium and grown under salinity conditions increase in medvein thickness by 26.6 % and lamina thickness by 22.7% more than those of salinity alone. The increase in lamina could be attributed to the increase in thickness of mesophyll tissues. The increments over the control were 28 and 32 % for the thickness of palisade and spongy tissues, respectively, while upper epidermis thickness decreased by 14.4%, lower epidermis not affected. Such treatment increased medvein bundle length by 25 % over the control. Medvein bundle width increased by 25 % over the control. The number of vessels/medvein bundles increased by 16.6 %. Moreover, the mean diameter of vessels increased by 49.5 %.

Plants treated with silicon and grown under salinity conditions induced a prominent increase in lamina thickness by 3.3 % more than those of salinity alone, while medvein thickness decreased by 16.6 %. The increase in lamina thickness which was observed could be attributed mainly to the increase in thickness of palisade and spongy tissues by 18.8 and 3.4% over those of control plants, respectively. While upper epidermis thickness decreases by 42.7%, lower epidermis is not affected. Also, dimensions of medvein bundle decrease in length by 16.6% and in width by 37.5 %. The number of vessels/medvein bundles decreased less than the control by 16.7 %. Vessel diameter not affected. Similar results were also reported by **Boghdady *et al*.(2017)** found that Foliar application of 10 ppm selenium induced favorable enhancement in anatomical feature of leaves. Increased thickness of both midvein and lamina, increased thickness of mesophyll size of midvein bundle, length and width of midvein bundle and vessel diameter were increased as a result of spraying selenium.

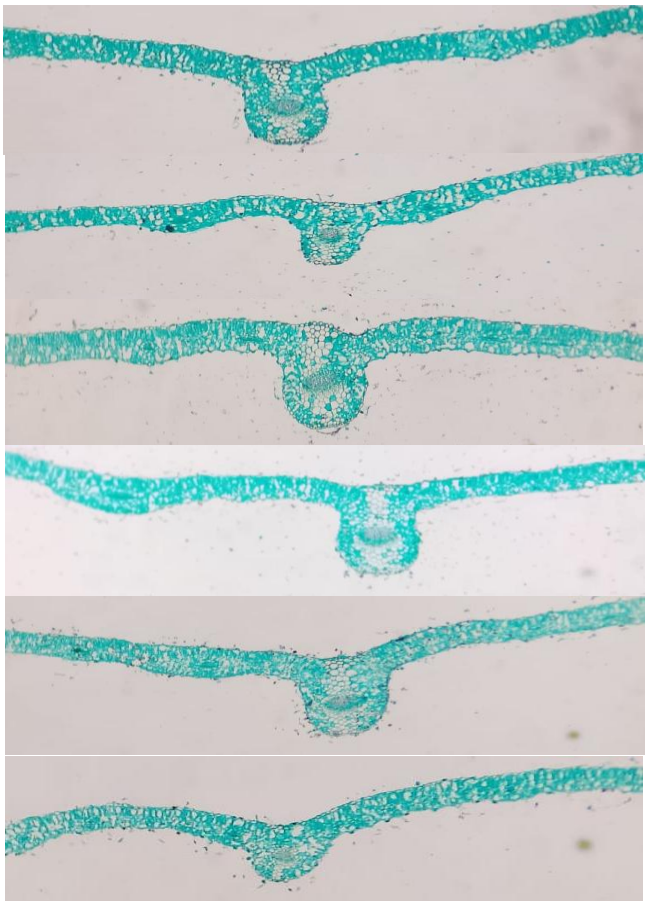
\

Table 11. Effect of salinity (2000 ppm), selenium (200ppm) and silicon (200ppm) on leaf anatomy of *Lavandula officinalis* after 70 day from planting during the second growing season 2024

Characters of leaf anatomy	control	Salinity 2000 ppm	±% to control	Selenium 200ppm	±% to control	Silicon 200ppm	±% to control
Midvein thickness (µ)	666.6	508.2	- 23.7	772.3	+ 15.8	762.3	+ 14.3
Lamina thickness (µ)	205.4	148.5	- 27.7	222.7	+ 8.4	169.1	- 17.7
Upper epidermis (µ)	17.3	17.3	-	19.8	+ 14.4	9.9	- 42.7
Lower epidermis (µ)	9.9	9.9	-	9.9	-	9.9	-
Palisade tissue (µ)	74.2	52.0	-30.0	86.6	+ 16.7	80.0	+ 7.8
Spongy tissue (µ)	106.4	69.3	- 34.8	106.4	-	69.3	- 34.8
Midvein bundle length (µ)	148.5	118.8	- 20.0	142	- 4.3	168.3	+ 13.3
Midvein bundle width (µ)	198.0	158.4	- 20.0	290.4	+ 46.6	221.1	+11.6
Number of vessels/medvein bundle	8.0	6.0	-25.0	10.0	+25.0	12.0	+ 50.0
Xylem vessels diameters (µ)	18.1	9.9	- 45.4	19.8	+ 9.4	18.1	-

Table 12. Effect of interaction between salinity (2000 ppm) + selenium (200 ppm) and salinity (2000 ppm) + silicon (200 ppm) on leaf anatomy *Lavandula officinalis* after 70 day from planting during the second growing season 2024

Characters of leaf anatomy	Salinity 2000 ppm	Selenium200 ppm + salinity 2000ppm	±% to salinity	Silicon 200 ppm + Salinity 2000ppm	to salinity
Midvein thickness (µ)	508.2	643.5	+ 26.6	426.5	-16
Lamina thickness (µ)	148.5	182.2	+22.7	153.4	+3.3
Upper epidermis (µ)	17.3	14.8	- 14.4	9.9	- 42.7
Lower epidermis (µ)	9.9	9.9	-	9.9	-
Palisade tissue (µ)	52.0	66.0	+28.0	61.8	+ 18.8
Spongy tissue (µ)	69.3	91.5	+32.0	71.7	+3.4
Midvein bundle length (µ)	118.8	148.5	+ 25.0	99.0	- 16.6
Midvein bundle width (µ)	158.4	198.0	+ 25.0	99.0	- 37.5
Number of vessels/medvein bundle	6.0	7.0	16.6+	5.0	-16.6
Xylem vessels diameters (µ)	9.9	14.8	+49.5	9.9	-



A- From control plant.

B- From plant grown under salinity at level 2000 ppm.

c- From plant treated with Selenium at level 200 ppm.

D- From plant treated with Silicon at level 200 ppm.

E- From plant treated with Selenium at level 200 ppm and grown under salinity at level 2000 ppm.

F- From plant treated with Silicon at level 200 ppm and grown under salinity at level 2000 ppm.

Figure 1 Transverse sections through the blade of the growing leaves on the first basal branch of *Lavandula officinalis* plants aged 70 days . (X 100)

REFERENCES

[1] Abo-Kassem E. E. M. (2006). Effects of salinity: Calcium interaction on growth and nucleic acid metabolism in five species of chenopodiaceous. Turk J Bot. 31; 125-134.

[2] Boghdady, M.S., E.M. Desoky, S.N. Azoz, M. Dalia and Nassar, A. (2017). Effect of selenium on growth, physiological aspects and productivity of faba bean (Vicia faba L.). Egypt. J. Agron., 39(1):83- 97.

[3] Duncun, D.B. (1955). Multiple ranges and multiple F test. Biometrics, 11: 1-42.

[4] Ellman, M. (1959). Aspectrophotometric method for determination of reduced glutathione in tissues. AnalytBiochem, 74; 214–226.

[5] Evenhuis, B. and PWDe Waard (1980). Principle and practies in plant analysis FAOSoils Bell. 38 (1) :152-163.

[6] Feng, R., C.Wei and S.Tu (2013). The roles of selenium in protecting plants against abiotic stresses. Environ. Exp. Bot., 87; 58–68.

[7] Ghasemian, S., N. Masoudian, F. Saeid Nematpour and A. Safipour Afshar(2021). Selenium nanoparticles stimulate growth, physiology and gene expression to alleviate salt stress in Melissa officinalis. Biologia, 76(10):2879-2888.

[8] Gonzalez-García. Y., C. Cardenas-Alvarez, G.Cadenas-Pliego, A. BenavidesMendoza, M. Cabrera-de-la-Fuente, A. Sandoval-Rangel, J. Vald es-Reyna, A. Ju arez-Maldonado(2021). Effect of three nanoparticles (Se, Si and Cu) on the bioactive compounds of bell pepper fruits under saline stress, Plants 10 (2):217

[9] Kato, R., and J. R. Gillette (1965). Effect of starvation on NADPH dependent enzymes in liver microsomes of male and female rats. Journal of Pharmacology and Experimental Therapeutics, 150(2): 279–284.

[10] Mozafariyan. M., M.M. Kamelmanesh and B. Hawrylak-nowak (2016). Ameliorative effect of selenium on tomato plants grown under salinity stress. Archives of Agronomy and Soil Science,

[11] 62(10):1368-1380.

[12] Mukherjee, S. P. and M. A. Choudhuri (1983). Implications of water stress-induced changes in the levels of endogenous ascorbic acid and hydrogen peroxide in Vigna seedlings. Plant Physiol., 58; 166-170.

[13] Nash, T. (1953). The colorimetric estimation of formaldehyde by means of the Hantzsch reaction. Biochemical Journal, 55(3):416.

[14] Nassar, M.A. and K.F. El-Sahhar (1998). Botanical Preparations and Microscopy (Microtechnique). Academic Bookshop, Dokki y, Giza , Egypt, pp.219 (In Arabic).

[15] Nishikimi, M., N. A. Rao and K.Yagi (1972). The occurrence of superoxide anion in the reaction of reduced phenazinemethosulfate and molecular oxygen.Biochemical and Biophysical Research Communications, 46(2): 849–854.

[16] Omura, T. and R. Sato (1964). The carbon monoxide-binding pigment of liver microsomes I. Evidence for its hemoprotein nature.Journal of Biological Chemistry, 239(7): 2370– 2378.

[17] Sachdev. S., S.A. Ansari, M.I. Ansari, M. Fujita and M. Hasanuzzaman, (2021) .Abiotic stress and reactive oxygen species: generation, signaling, and defense mechanisms antioxidants 10 (2) :277.

[18] Sajyan T.K, S.M.Alturki and Y.N. Sassine (2020) Nano-fertilizers and their impact on vegetables: contribution of Nano-chelate super plus ZFM and Lithovit®-standard to improve salt-tolerance of pepper. Annal Agr Sci. https://doi.org/10.1016/j.aoas.2020.11.001

[19] Shah. W.H., A. Rasool, I. Tahir and R.U. Rehman (2020). Exogenously applied selenium (Se) mitigates the impact of salt stress in Setaria italica L. and Panicum miliaceum L, Nucleus 63; 327–33.

[20] Sinha, A. K. (1972). Colorimetric assay of catalase.Analytical Biochemistry, 47(2): 389–394.

[21] Soliman, A. S., S. A. El-feky and E. Darwish (2015). Alleviation of salt stress on Moringa peregrina using foliar application of nanofertilizers. Journal of Horticulture and Forestry, 7(2):36-47.

[22] SPSS (2020). Statistical Package for Social Science, Version 20, Chicago, USA.

[23] Steel, R.G.D. and J.M. Torrie (1980). Principles and Procedures of Statistics, A Biometrical Approach. McGraw - Hill Book Company, New York.

[24] Stefanakis, M. K., A. E. Giannakoula , G. Ouzounidou, C. Papaioannou, V. Lianopoulou, and E. Philotheou-Panou (2024). The effect of salinity and drought on the essential oil yield and quality of various plant species of the lamiaceae family (Mentha spicata L., Origanum dictamnus L., Origanum onites L.). Horticulturae, 10(3):265.

[25] Tappel, A. L. and H. Zalkin (1959). Inhibition of lipide peroxidation in mitochondria by vitamin E. Archives of Biochemistry and Biophysics, 80(2): 333–336.

[26] Vasileva, I., R. Denkova, R. Chochkov, D.Teneva, Z. Denkova, T. Dessev and A. Slavov (2018). Effect of lavender (Lavandula angustifolia) and melissa (Melissa Officinalis) waste on quality and shelf life of bread. Food Chemistry, 253; 13-21.

[27] Wang, M., J. Yuan, L. Qin, W.Shi, G.Xia and S. Liu (2020). TaCYP81D5, one member in a wheat cytochrome P450 gene cluster, confers salinity tolerance via reactive oxygen species scavenging. Plant Biotechnol. J., 18; 791–804.

[28] Wu, B., A. Ootani, R. Iwakiri, Y. Sakata, T. Fujise, S. Amemori and K. Fujimoto (2006). Cell deficiency leads to liver carcinogenesis in Azoxymethane-treated rats. Experimental Biology and Medicine, 231(1): 91-98.

-.