Evaluation the Impact of Salicylic Acid on *Origanum Syriacum* L. Plant Tolerance to Saline Water Irrigation under North Sinai Conditions

Hanfy, M.R.[1]; El-Shafay[1], R.M.M.A.; Ali [2] M.A.M and Abdallah[2] S.A.S.

[1.] Med. and Aromatic Plants Dept, Des. Res. Cent., El-Mataria, Cairo, Egypt**.**

[2.] Plant Prod. Dept. Fac. Environ. Agric. Sci.; Arish Univ., Egypt.

ABSTRACT

This experiment was carried out at North Sinai Research Station Farm, 30 Km East El-Arish City (North Sinai Governorate), Desert Research Center, Egypt during the two consecutive seasons of 2014 and 2015, to study the effect of spraying with different concentrations of salicylic acid on vegetative growth parameters, essential oil yield and chemical constituents of *Origanum syriacum,* L. plant under saline water irrigation (about 3000 ppm) stress conditions. This experiment included 4 treatments, which were four concentrations of salicylic acid (0, 500, 750 and 1000 mg/l) sprayed on plants. Treatments were arranged in a complete randomize design with three replicates. The results indicated that all the measurements (plant height, herb fresh and dry weights per/plant, herb fresh and dry weights per feddan, oil percentage of herb, oil yield per plant and per feddan as well as total nitrogen, phosphorus and potassium percentages) were increased with increasing the concentration of salicylic acid, as there was a direct relationship between the increase in the concentration of salicylic acid and the increase in the characteristics under study. So that our recommendation is to spray *Origanum syriacum,* L. plants with 1000 mg /l of salicylic acid to gain the maximum yield of herb an essential oil from this plant.

Keywords: Salicylic acid - *Origanum syriacum,* L- Saline water irrigation - Stress conditions

INTRODUCTION

Origanum syriacum L. belongs to *Lamiacea*e family is a medicinal plant with a great economic importance. It is a large herbaceous plant, reaching a height of 50 cm. Its leaves are small, gray in color and the flowers are blue in clusters, and the fruits are small capsules with small wrinkled seeds (Elhage, 2000). The percentage of essential oil in the leaves is ranged between 1 to 2.5%, which is characterized by the smell of camphor, and the main component of the oil is thymol (Amar and Abdel-Wahab, 2013 and Khater, 2020).

Salicylic acid could improve plant productivity and resistance to salinity damage which resulted from salinity of irrigation water or soil. Poor et al. (2011). Shalaby and Razin (1992) stated that spraying with salicylic acid led to increase the efficiency of root system for absorption of nutrients. Also, Hamid et al. (2012) observed an improvement in plant growth as a result of spraying with salicylic acid under saline water irrigation conditions. Moreover, Bastam et al. (2013) detected an increase in the efficiency of photosynthesis and nutrients absorption for plants grown under

salt stress conditions when treated with salicylic acid. In addition, Al-Taey (2010) found that spraying olive plants with salicylic acid resulted in improving plant tolerance to saline water irrigation, which would improve plant production, as an increase in plant height, number of branches, and fresh and dry weight of plants.

This research aims to study the effect of spraying with different concentrations of salicylic acid on improving the vegetative growth and production of the essential oil of *Origanum syriacum*, L. under saline water irrigation conditions in North Sinai.

MATERIALS AND METHODS

This experiment was conducted to study the effect of spraying with different concentrations of salicylic acid on vegetative growth, essential oil yield and chemical constituents of *Origanum syriacum*, L. plant. This experiment was carried out at North Sinai Research Station Farm, which located 30 Km East El-Arish City (North Sinai Governorate), Desert Research Center, Egypt during two consecutive seasons (2014 and 2015). Seedlings of *Origanum syriacum* L. were obtained from North Sinai Research Station, Desert Research Center, North Sinai Governorate. Homogenous seedlings with 12-15 cm height were transplanted in the field on 12th April 2014 and 18th April 2015 at distances of 50 cm between plants and 100 cm between rows (8400 plants/fed.). Irrigation system was drip irrigation with the rate of 4 l/h for one hour every 3 days with saline well water (3000 ppm). The chemical analysis of irrigation water, physical and chemical analyses of experimental farm soil are shown in Tables A and B, respectively. These analysis were done according to methods described by Richards (1954).

Table (A). Some chemical and physical characteristics of irrigation water

EC ($dS.m^{-1}$)	pH	Cations ($meq.l^{-1}$)				Anions ($meq.l^{-1}$)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
4.46	7.8	8.5	9.29	23.5	0.18	1.00	3.00	27.5	9.97

Table (B): Some chemical and physical characteristics of experimental farm soil at 0-30 cm depth

Chemical analysis

Cations ($meq.l^{-1}$)				Anions ($meq.l^{-1}$)				EC ($d.Sm^{-1}$)	PH	Available micronutrients in soil (ppm)			
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	Co_3^{--}	Hco_3^{-}	So_4^{--}			Fe	Zn	Cu	Mn
20.0	7.8	14.1	1.0	25.6	-	3.1	14.2	4.29	8.00	2.8	3.6	0.7	5.4

Mechanical analysis

Clay	Silt	Sand	Texture calls
2.1 (%)	4.9 (%)	93.3 (%)	Sandy soil

This experiment included 4 treatments, which were four concentrations of salicylic acid (0, 500, 750 and 1000 $mg.l^{-1}$). Treatments were arranged in a complete randomize design with three replicates. Salicylic acid was applied as a foliar application (three sprays per season, every ten days started after two weeks from transplanting). It was dissolved in weak water (0.2 mg/100 H_2O at 20° C). The acetyl salicylic acid was obtained from Abo Ghaneima Co. for Fertilizer and Chemical Industries, Egypt. All agricultural practices were implemented as usual.

Recorded data:

After eight weeks from planting date the following data were recorded i.e.; plant height (cm), herb fresh and dry weights per/plant (gm)**,** herb fresh and dry weights per feddan (kg)**.** Also, herb oil percentage was esimated according to British Pharmacopoeia (1936) and oil yield per plant (ml) and per feddan (L) were calculated. In addition, chemical constituents viz. total nitrogen, phosphorus and potassium percentages were determined according to Pregl (1945, Murphy and Riely (1962) and Jackson and Ulrich (1959), respectively.

- **Statistical analysis:** All obtained data during both seasons were subjected to statistical analysis according to Snedecor and Cochran (1972). Means values represented the various investigated treatments were compared by using Duncan`s multiple range test (Duncan, 1955) at 5 % level of significance.

RESULTS

1- Plant height (cm):

All salicylic acid concentrations led to an increase in plant height **(Table 1).** This increase was significant during the first and second seasons at both cuts. Plant height was enhanced as salicylic acid concentration increased. Spraying plants with salicylic acid at 1000 mg/l resulted in the highest values (31.71 and 32.12 cm) of plant height during both seasons, respectively. **(Table 1).**Moreover, plants obtained from second cut were significantly taller than those obtained from first cut during both seasons.

Table (1). Effect of different concentrations of salicylic acid on plant height (cm) of *Origanum syriacum* L. during both seasons

Salicylic acid (mg/l)	Plant height (cm)		
	Cut 1	Cut 2	Mean
		First season	
0	27.73 g	30.37 e	**29.05 D**
500	28.83 f	31.07 c	**29.95 C**
750	30.57 d	31.85 b	**31.21 B**
1000	31.07 c	32.34 a	**31.71 A**
Mean	**29.55 B**	**31.41 A**	
		Second season	
0	28.19 f	30.93 d	**29.56 D**
500	29.49 e	31.35 c	**30.42 C**
750	30.97 d	32.19 b	**31.58 B**
1000	31.31 c	32.93 a	**32.12 A**
Mean	**29.99 B**	**31.85 A**	

Means in a column or raw followed by the same letter do not differ significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

2. Herb fresh and dry weights/plant (gm).

Regarding to spraying oregano plant with salicylic acid, this led to a significant increase in the fresh weight of herb **Table (2).**There was a positive relationship between salicylic acid concentration and herb fresh or dry weights/plant. The maximum values of these parameters were detected with the highest salicylic acid concentration (1000 mg/l **(Table 2).** Fresh and dry weights of herb obtained

from second cut were significantly higher than those produced from first cut during both seasons.

Table (2). Effect of different concentrations of salicylic acid on herb fresh and dry weights/plant (g) of *Origanum syriacum* L. during both seasons

Salicylic acid (mg/l)	Herb fresh weight/plant (gm).			Herb dry weight/plant (gm).		
	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean
			First season			
0	63.33 h	78.42 f	**70.88 D**	21.11 h	26.14 f	**23.63 D**
500	73.89 g	88.39 e	**81.14 C**	24.63 g	29.46 e	**27.05 C**
750	111.11 d	117.79 c	**114.50 B**	34.04 d	39.30 c	**38.17 B**
1000	120.00 b	123.86 a	**121.93 A**	40.00 b	41.29 a	**40.65 A**
Mean	**92.08 B**	**102.14 A**		**30.70 B**	**34.05 A**	
			Second season			
0	74.23f	86.42e	**80.33D**	24.74f	28.81e	**26.78D**
500	86.31e	97.21d	**91.76C**	28.77e	32.40d	**30.59C**
750	119.14b	111.22c	**115.18B**	39.71b	37.07c	**38.39B**
1000	121.24a	118.89b	**120.07A**	40.41a	39.63b	**40.02A**
Mean	**100.23B**	**103.44A**		**33.41B**	**34.48A**	

Means in a column or raw followed by the same letter do not differ significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

3. Herb fresh and dry herb weights/feddan (kg):

Table (3) demonstrates that there are significant differences in fresh and dry herb yields per feddan (kg) as a result of treating plant with different concentrations of salicylic acid. The highest significant increases in these parameters were recorded in both seasons when plants were treated with 1000 mg/liter salicylic acid. These increases in fresh and dry herb yields per feddan were 89 and 58 % compared to control treatment, at first and second cuts in first season, respectively. While, during second season it reached 63 and 38 % compared to control treatment at first and second cuts, respectively.

Table (3). Effect of different concentrations of salicylic acid on herb fresh and weights/fed (kg) of *Origanum syriacum* L. during both seasons

Salicylic acid (mg/l)	Fresh herb yield (kg/fed)			Dry herb yield (kg/fed)		
	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean
			First season			
0	532.0 h	658.7 f	**595.4 D**	177.3 h	219.6 f	**198.5 D**
500	620.7 g	742.5 e	**681.6 C**	206.9 g	247.5 e	**227.2 C**
750	933.3 d	990.3 c	**961.8 B**	311.1 d	330.1 c	**320.6 B**
1000	1008.0 b	1040.4 a	**1024.2 A**	336.0 b	346.8 a	**341.4 A**
Mean	**773.5 B**	**858.0 A**		**257.8 B**	**286.0 A**	
			Second season			
0	623.5 f	725.9 e	**674.7 D**	207.8 f	242.0 e	**224.9 D**
500	725.0 e	816.6 d	**770.8 C**	241.7 e	272.2 d	**256.9 C**
750	1000.8 b	934.3 c	**967.5 B**	333.6 b	311.4 c	**322.5 B**
1000	1018.4 a	998.7 b	**1008.6 A**	339.5 a	332.9 b	**336.2 A**
Mean	**841.9 B**	**868.9 A**		**280.6 B**	**289.6 A**	

Means in a column or raw followed by the same letter do not differ significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

4. Essential oil (%):

Data in **Table (4)** show that as salicylic acid concentration increased of, a significant increase was observed in the essential oil percentage of oregano leaves. This increase reached its maximum values when plants were sprayed with 1000 mg/l salicylic acid at both cuts during both seasons. Moreover, essential oil percentage was higher at second cut compared with first cut.

5. Essential oil yield per plant (ml)

Table (4) illustrates that there was a significant increase in the essential oil yield per plant of oregano plant as salicylic acid concentration elevated. The highest value was detected when plants were sprayed with salicylic acid at the highest concentration (1000 mg/l). The percentage of increase over control treatment reached 156 and 109 %at the second cut during both seasons, respectively. Also, the same treatment gave the highest increase in essential oil yield per plant of oregano plant at first cut, where the increase was 128 and 93 %during both seasons, respectively.

6. Essential oil yield per feddan (l):

Data in **Table (4)** indicates that there was a significant increase in the essential oil yield per feddan (l) of the oregano plant as a result of using the highest concentration of salicylic acid (1000 mg/l). This increase reached 158 and 108 %at both cuts during the first season, respectively. Moreover, this increase reached 130 and 92 (%) during the second season at both cuts, respectively.

Table (4). Effect of different concentrations of salicylic acid on essential oil (%) and essential oil yield per plant (ml) and per feddan of *Origanum syriacum* L. during both seasons

Salicylic acid (mg/l)	Essential oil (%)			Essential oil yield/plant (ml)			Essential oil yield / feddan (Lf)		
	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean
First season									
0	2.35 g	2.84 f	**2.60 D**	0.50 g	0.64 f	**0.57 D**	4.17 h	6.24 f	**5.21 D**
500	3.03 e	3.41 c	**3.22 C**	0.72 e	0.85 d	**0.79 C**	6.08 g	8.44 e	**7.26 C**
750	3.20 d	3.68 b	**3.44 B**	1.12 c	0.90 d	**1.01 B**	9.43 d	12.15 b	**10.79 B**
1000	3.94 a	3.75 b	**3.85 A**	1.28 b	1.46 a	**1.37 A**	10.75 c	13.01 a	**11.88 A**
Mean	**3.13 B**	**3.42 A**		**0.91 B**	**0.96 A**		**7.61 B**	**9.96 A**	
Second season									
0	2.57 d	2.65 d	**2.61 D**	0.74 f	0.76 f	**0.75 D**	5.34 g	6.41 f	**5.88 D**
500	2.95 c	3.49 b	**3.22 B**	1.00 e	1.13 d	**1.07 C**	7.13 e	9.50 c	**8.32 C**
750	2.27 e	3.63 a	**2.95 C**	1.45 b	1.35 c	**1.40 B**	7.57 d	11.30 b	**9.44 B**
1000	3.62 a	3.70 a	**3.66 A**	1.55 a	1.47 b	**1.51 A**	12.29 a	12.32 a	**12.31 A**
Mean	**2.85 B**	**3.37 A**		**1.19 A**	**1.18 A**		**8.08 B**	**9.88 A**	

Means in a column or raw followed by the same letter do not differ significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

7. Chemical constituents (N, P and K percentages)

Data in **Table (5)** show the effect of spraying plants with different concentrations of salicylic acid on the percentages of the major nutrient elements (nitrogen, phosphorous and potassium). It was revealed that during both seasons at both cuts, the application of salicylic acid at 1000 mg/l resulted in significant increase in the

percentages of nitrogen, phosphorus and potassium compared to other treatments. In general, all salicylic acid concentrations enhanced the percentages of nitrogen, phosphorous, and potassium in the leaves of the plants compared to the untreated plants.

Spraying plants with salicylic acid at 1000 mg/l gave the highest percentage of nitrogen (2.76 and 2.79 %) and (3.14 and 3.17 %), phosphorus (0.261 and 0.271 %) and (0.300 and 0.310 %) and potassium (1.83 and 1.79 %) and (2.21 and 1.93 %) at first and second cuts during both seasons, respectively.

On the other side, the lowest values of those characteristics were detected with untreated plants, which gave the lowest percentages of nitrogen (2.33 and 2.18 %) and (2.89 and 2.88 %), phosphorous (0.24 and 0.228 %) and (0.244 and 0.246 %) and potassium (1.42 and 1.38 %) and (1.95 and 2.06 %) at first and second cuts during both seasons, respectively.

The best treatment to increase the percentages of nitrogen, phosphorus and potassium in the leaves of the plant was spraying plants at 1000 mg/liter, followed by spraying at a concentration of 750 mg/liter, then spraying at a concentration of 500 mg/liter, respectively.

Table (5). Effect of different concentrations of salicylic acid on N, P and K percentages of *Origanum syriacum* L. during both seasons

Salicylic acid (mg/l)	N (%)			P (%)			K (%)		
	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean	Cut 1	Cut 2	Mean
First season									
0	2.33 d	2.18 e	**2.26C**	0.240 cd	0.228 d	**0.234 B**	1.42 bc	1.38 c	**1.40 C**
500	2.40 d	2.45 c	**2.43B**	0.259 a-c	0.265 ab	**0.262 A**	1.50 b	1.73 a	**1.62 B**
750	2.74 b	2.86 a	**2.80A**	0.242 cd	0.249 bc	**0.246 B**	1.75 a	1.74 a	**1.75 A**
1000	2.76 b	2.79 ab	**2.78A**	0.261 a-c	0.271 a	**0.266 A**	1.83 a	1.79 a	**1.81 A**
Mean	**2.56 A**	**2.57 A**		**0.251 A**	**0.253A**		**1.63 A**	**1.66 A**	
Second season									
0	2.89 d	2.88 d	**2.89C**	0.244 d	0.246 cd	**0.245 C**	1.95 d	2.06 bc	**2.01 C**
500	2.91 d	2.94 cd	**2.93C**	0.264 bc	0.273 b	**0.269 B**	2.03 c	1.85 e	**1.94 D**
750	3.10 ab	3.01 bc	**3.06B**	0.256 b-d	0.253 cd	**0.255 C**	2.13 b	2.21 a	**2.17 A**
1000	3.14 a	3.17 a	**3.16A**	0.300 a	0.310 a	**0.305 A**	2.21 a	1.93 d	**2.07 B**
Mean	**3.01 A**	**3.00 A**		**0.266A**	**0.271 A**		**2.08 A**	**2.01 B**	

Means in a column or raw followed by the same letter do not differ significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

DISCUSSION

Obtained results demonstrate that all growth characteristics under study were significantly improved by spraying plants with salicylic acid especially at the highest concentration (1000 mg/l). These results are in line with those found by Al-Taey (2010) on *Olea europeae* L., Bayat et al. (2012) on *Calendula officinalis* L., Refat et al. (2017) on sunflower plant, El-Esawi et al. (2017) on rosemary and Khater (2020) on *Origanum Majorana* plant. Salicylic acid has an important role in increasing the division of the cell inside the plant tissues responsible for the increase in growth, which was reflected on the increase in plant height. Salicylic acid, also plays a prominent role in increasing the dry and fresh weight of the vegetative growth due to a direct effect in

improving the characteristics of vegetative growth, including plant height and leaf area, and this is due to the hormonal role in increasing the growth of the plant cell and the amount of materials manufactured in the leaves after the process of photosynthesis and the transfer of nutrients from the leaves to the rest of the plant parts to increase the growth of plants Hayat et al. (2010). Our results proved the superiority of oil percentage in plants sprayed with 1000 mg/l salicylic acid. This improvement in essential oil production can be attributed to the effect of salicylic acid on increasing the percentage of internal hormones represented by auxin and interfering with enzymes for the purpose of forming nucleic acids RNA, DNA and proteins that in turn increase the production of essential oil as a result of the increase in the rate of photosynthesis, which is reflected on the increase in the amount of leaves and the increase in the fresh and dry weight of the leaves which in turn increases the leaf content of the essential oil for each plant and per feddan Khan et al. (2003).

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الملخص العربى

تقييم تأثير حمض الساليسيليك على تحمل نبات الأوريجانو السوري (*Origanum Syriacum* L.) لري المياه المالحة تحت ظروف شمال سيناء

محمد رضا حنفي[1]؛ رمضت محيي الدين محمد الشافعي[1]؛ محمد أحمد محمود علي[2] وسونيا عطيه شحاته عبد الله[2]

1. قسم النباتات الطبية والعطرية، مركز بحوث الصحراء، المطرية، القاهرة، مصر .

٢. قسم الإنتاج النباتي، كلية العلوم الزراعية البيئية؛ جامعة العريش، مصر.

تم إجراء التجربة في محطة بحوث شمال سيناء الزراعية، على بعد 30 كم شرق مدينة العريش (محافظة شمال سيناء)، مركز بحوث الصحراء، مصر خلال الموسمين المتتاليين 2014 و2015، لدراسة تأثير الرش بتركيزات مختلفة من حمض الساليسيليك على النمو الخضري، وإنتاج الزيت العطري، والمكونات الكيميائية لنبات الأوريجانو السوري تحت ظروف إجهاد الري بمياه مالحة (حوالي 3000 جزء في المليون). شمل هذا التجربة 4 معاملات، وهي أربع تركيزات من حمض الساليسيليك (0، 500، 750 و1000 ملغ/لتر) التي تم رشها على النباتات، وتم ترتيب المعاملات في تصميم عشوائي كامل مع ثلاث مكررات.

أشارت النتائج إلى أن جميع القياسات زادت مع زيادة تركيز حمض الساليسيليك، حيث كانت هناك علاقة مباشرة بين زيادة تركيز حمض الساليسيليك وزيادة الخصائص المدروسة. أظهرت التحليلات الإحصائية للبيانات أن هناك زيادة كبيرة أدت إلى زيادة في كل من أرتفاع النبات والوزن الطازج والجاف للعشب لكل نبات. كل فدان كان يحتوي أيضًا على محتوى الزيت في الأوراق ومحتوى العشب من الزيت الطيار لكل نبات ولكل فدان. كما زادت العناصر الرئيسية النيتروجين والفوسفور والبوتاسيوم زيادة ملحوظة في تركيز حمض الساليسيليك، حيث كان أفضل علاج هو الرش بتركيز 1000 ملجم/لتر من حمض الساليسيليك.