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USING SALICYLIC ACID AND HUMIC ACID AS FOLIAR APPLICATION IN AMENDING THE HARMFUL INFLUENCE OF SOIL SALINITY STRESS IN COMMON SAGE (*SALVIA OFFICINALIS* L.)

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ABSTRACT

In order to amend the harmful effect of soil salinity stress in common sage plants by foliar spray with salicylic acid (SA) and humic acid (HA), two pot experiments were conducted at the Nursery of ornamental plants, Agric. Fac., Zagazig Univ., Sharkia Governorate, Egypt in lath house during the two winter consecutive seasons of 2018/2019 and 2019/2020. The aiming of this work was to investigate the effect of foliar application treatments i.e., sprayed with distilled water (control), 200 ppm salicylic acid (SA), 750 ppm humic acid (HA), 1500 ppm HA, 200 ppm SA+750 ppm HA and 200 ppm SA+1500 ppm HA under various soil salinity levels (0.0, 1000 and 2000 ppm) as well as their combinations on yield components, salt resistance index and volatile oil production as well as some chemical constituents of *Salvia officinalis* plants. These experiments were arranged in a split-plot design with three replicates. The main plots were occupied by different soil salinity levels and the sub plots were entitled to different salicylic acid and humic acid acids concentrations. The obtained results referred to that herb fresh and dry weights per plant as yield components, volatile oil percentage and volatile oil yield per plant as volatile oil production as well as salt resistance index (%) were recorded. Also, total carbohydrates percentage and total chlorophyll (SPAD unit) in sage leaves was determined. Results showed that using soil salinity levels (1000 and 2000 ppm) significantly decreased yield components, volatile oil yield per plant, total carbohydrates percentage and total chlorophyll content compared to control. In contrast, increasing soil salinity levels gradually increased volatile oil percentage and proline content. In addition, the maximum values of the most of all above mentioned traits were achieved by treating sage plants with 200 ppm SA+1500 ppm HA. Generally, it could conclude that 200 ppm SA+750 or 1500 ppm HA, showed a uniform influence in qualifying of common sage yield inhibition and increasing salt resistance index under moderate salinity stress (1000 ppm level) condition.

Keywords: *Salvia officinalis*, Soil salinity, Salicylic acid, Humic acid, Yield, Salt resistance, Volatile oil, Total chlorophyll

INTRODUCTION

Common sage (*Salvia officinalis*, L.) is aperennial and herbaceous plant belongs to family Labiatae and is native to Mediterranean region and currently cultivated in dry areas of America, Asia, Europe and North Africa. Aromatic and medical plants have been major components of healthcare over human history (Schippmann *et al*., 2002). Common sage (salvia) is one of the most remarkable aromatic and medicinal plants, with specific sensorial attributes, antioxidant, spasmolytic, anti hidrotic, antimicrobial and astringent (Yadegari and Shakerian, 2014). As renowned, the yield, volatile oil attributes and the biosynthesis of chlorophyll influenced by various environmental factors namely the foliar spraying with salicylic and humic acids (Peña-Méndez *et al*., 2005, Abreuand Munnee´-Bosch, 2008 and Rowshan *et al*., 2010), as well as soil salinity level (Biswas *et al*., 2011). This biotic limitation is established to convert yield and quality in several plants (Karimian *et al*., 2019; Es-sbihi *et al*., 2020).

Soil salinity stress negatively impacts plant vegetative growth and yield due to the influences, nutritional imbalance as well as low osmotic prospect of soil solution and integrations of these factors (Ashraf and Harris, 2004).The high salinity of the soil impacts the soil penetration, lowered the soil water potential and in last caused physiological dehydration (Yusuf *et al*., 2008). Generally, under salinity condition changes the plants metabolisms to beat the changed environmental conditions. One mechanisms utilized by the plants for overcoming the salt stress effects might be by means of accumulation of proper osmolytes, such as proline and soluble sugar. Accumulation of free amino acids and production, particularly proline by plant tissue during water and salt stress is an adaptive reaction (Sahar *et al*., 2011).

Salicylic acid (SA) is a phenolic compound in plant and today it is known as interior regulator hormone, because its function in the defensive mechanization versus biotic and abiotic stresses has been definite (He *et al*., 2005).The exogenous application of SA has been notified to motivate tolerance to soil salinity stress (Jayakannan *et al*., 2015). SA mitigated the inverse impact of salt stress by lessening K^+ leakage from tissues of root and by promoting the H^+-ATPase activity (Jayakannan *et al*., 2013), which supplies a driving force for Na^+/H^+ exchanger at the plasma membrane and leads to decreased Na accumulation in the cytosol (Shi *et al*., 2000).Humic acid (HA) treatments get better soil air conditioning, aggregation, water permeability, structure, fertility, and moisture holding capacity as well as raises microbial action of microbial population and cation interchange capacity (Mohamed, 2012). In addition, they are responsible for the herb yield of the plants such as total dry herb yield per plant as well as total chlorophyll content and they are included in some biological process such as the production of plant development-effects substances as free enzymes (Mohammed *et al*., 2019).

So, the main goal of this study was to find the mitigating effect of salicylic and humic acids on herb yields, volatile oil percentage and yield per plant and salt resistance index as well as total chlorophyll content of sage plants under salt stress.

MATERIALS AND METHODS

A preliminary experiment was carried out at 10th March 2018 on the influence of soil salinity levels on common sage plants, including 0.0, 1000, 2000 and 3000 ppm. Only the development and growth of 0.0, 1000 and 2000 ppm levels was noticed, while plants at a high soil salinity level (3000 ppm) were died, therefore, the experiment was completed on the influence of soil salinity levels on 0.0, 1000 and 2000 ppm levels only. A lath house, two experiments were carried out at the Nursery of ornamental plants, Horticulture Department, Zagazig University, Sharkia Governorate, Egypt during the two winter consecutive seasons of 2018/2019 and 2019/2020.A total of 270 transplants [(3soil salinity × 6 salicylic and humic acid treatments) × 3 replicates× 5transplants) were transplanted into pots (30 cm diameter,30 cm depth and 12 kg capacity) filled with a soil that its texture was sand: clay (1:1 *v/v*).The physical and chemical properties of the utilized soil mixture (average of the two seasons) are presented in Table 1 according to Chapman and Pratt (1978). Attention had been driven to follow the changes in herb yield, volatile oil production, salt resistance index and total carbohydrates percentage, total chlorophyll content of sage (*Salvia officinalis*, L.) plants in order to obtaining results from applying salinity levels as well as SA and HA acids combination treatments.
This experiment was carried out utilizing a split-plot in randomized complete block design with three replications. The first factor (main plot) studied included three salinity levels (0.0, 1000 and 2000) that were utilized the certain amounts of sodium chloride in distilled water. The three levels of artificial soil salinity were utilized by dissolving the natural salt crust of sea water in distilled water then added to the soil based on its weight. The chemical analysis of salt is shown in Table 2.The second factor (sub plot) studied included six acids concentrations [control (sprayed with distilled water), salicylic acid (SA) at 200 ppm, humic acid (HA) at 750 ppm, 1500 ppm HA, 200 ppm SA+750 ppm HA and 200 ppm SA+1500 ppm HA)] as foliar spray. The combination treatments between soil salinity level as well as SA and HA acids concentrations were consisted of 18 treatments.

Seedlings of common sage (salvia) were obtained from a private nursery in Belbas District (called Mostafa Aboesa Nursery), Sharkia Governorate, Egypt and were planting on the 1stOctober during 1st and 2ndseasons. All seedlings were similar in growth and 10 cm in height. One seedling was planted per pot. All recommended agricultural practices of growing common sage plants were done when ever needed. However, common sage plants were foliar sprayed with SA and HA acids concentrations four times at 30, 45, 60 and 75 days after planting date. The source of salicylic acid ($C_7H_6O_3$) was Techno Gene Company (TGC), Dokky, Giza, Egypt. Vegetarian humic acid fertilizer (Abo Zaabal Company to Fertilizers) contains 86% humic acid.

The basal rates of nitrogen (N), phosphorous (P_2O_5) and potassium (K_2O) were applied in each pot at the rate of 140 mg/kg, 60 mg/kg and 40 mg/kg through ammonium sulphate (20.5 % N), single superphosphate (15.5 %P_2O_5) and potassium sulphate (48 % K_2O), respectively, at 35, 55 and 75 days of planting date.

Data recorded

A random sample of three plants from each sub plot was taken at 88 to 125 days after planting and the following data were recorded:

1. Yield components: Fresh and dry herb yield (it is dried in oven at 45ºC) per sage plant were determined after 125 days of planting date in the two consecutive seasons.

2. The salt resistance index (SRI %): As a real indicator for salinity tolerance was calculated from the equation mentioned before by Abdelkader *et al*., (2019) on rosemary: SRI (%) = Mean fresh herb yield per plant of the salt treated plants/mean fresh herb yield per plant of control one × 100.

3. Volatile oil production: After 125 days from planting date, the volatile oil from dried herb of sage plants was isolated by hydro distillation for 3 hr., in order to extract the volatile oil according to Guenther (1961) and the volatile oil yield per plant (ml) was calculated.

4. Chemical constituents: Total chlorophyll content (SPAD)in fresh leaf samples of existing sage plants after 88 days from planting date during both seasons, it was measured by using SPAD- 502 meter as described by Markwell *et al*., (1995).Total carbohydrate percentage was determined according to the method described by Dubois *et al*., (1956).Furthermore, in sage dry leaves, the free amino acid proline (mg/g as dry weight) was determined by the method explained by Bates *et al.,* (1973).

Statistical Analysis

Data of the present study were statically analyzed according to Gomez and Gomez (1984) and the differences between the means of the treatments were considered significant when they were more than the least significant differences

(L.S.D) at the 5% levels by utilizing computer program of Statistix Version 9 (Analytical Software, 2008).

RESULTS AND DISCUSSION

1. Yield components

The data reported in Tables 3 and 4indicate that, utilizing soil salinity treatments significantly decreased herb fresh and dry yield per common sage plant compared to control in the two seasons. Moreover, sage yield components were gradually decreased with the increasing of the levels of salinity to reach its minimum by utilizing that of 2000 ppm. The fresh and dry herb yields were significantly greater in control (71.47 and 74.23g as well as 18.78 and 20.16g), which was closely followed by 10000 ppm (63.66 and 66.19g as well as 15.70 and 16.07g) in the 1st and 2nd seasons, respectively. However, salicylic and humic acids concentrations significantly increased salviafresh and dry herb yield per plant compared to untreated plants, in most cases, in both seasons. 200 ppm SA + 1500 ppm HA significantly increased fresh and dry herb yield per plant compared to control and the other ones under study (Tables3 and 4). Generally, the combination between soil salinity and SA and HA acids mostly decreased fresh and dry herb yield per sage plant comparing to control. Also, utilizing 200 ppm SA + 1500 ppm HA increased common sageyield components in comparison to the salinized plants under the same levels alone in the two consecutive seasons. Generally, the highest values in this connection were obtained from the combination treatment between 200 ppm SA+750 ppm HA and without soil salinity application in both seasons. Whenever, the increases in fresh herb per plant were about 24.66 and 34.15 % for the SA at 200 ppm + HA at 1500 ppm treatment under no salinity conditions compared to control in the 1stand 2nd seasons, respectively.

Table 1. Physical and chemical properties of experimental farm soil (average of two seasons)

			Physical analysis									Soil texture	
Clay (%)			Silt (%)				sand (%)					Sandy	
22.37			7.93				69.70						
			Chemical analysis										
Time	pH	E.C. (dsm^{-1})	Soluble cations (m.mol/l)					Soluble anions (m.mol/l)			Available (ppm)		
			Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
Before planting	**7.80**	0.58	1.80	0.95	0.30	1.10	1.32	3.04	1.12	0.84	127	46	51

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^{+}	HCO_3^{-}	CO_3^{--}	SO_4^{--}	Cl^{-}
171.3	9.28	8.54	3000.0	2.80	4.86	0.0	80.76	2935.00

Table 3. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on fresh weight of herb per plant (g) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	65.34	69.57	66.99	71.61	73.84	81.45	**71.47**
1000	54.50	60.68	60.58	64.78	68.28	73.12	**63.66**
2000	40.24	42.64	42.51	47.70	54.00	58.26	**47.56**
Means (A)	**53.36**	**57.63**	**56.69**	**61.36**	**65.37**	**70.94**	
L.S.D. at 5 %	**For (S)= 0.51**		**For (A)= 0.86**		**For (S×A)= 1.45**		
	2019/2020 season						
Control	63.34	72.49	71.23	74.94	78.41	84.97	**74.23**
1000	53.42	65.18	64.77	68.34	70.71	74.74	**66.19**
2000	37.63	42.93	43.85	50.48	54.19	62.00	**48.51**

Table 4. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on dry weight of herb per plant (g) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	14.46	17.13	16.55	19.34	21.14	24.04	**18.78**
1000	12.64	14.28	13.84	15.82	18.06	19.56	**15.70**
2000	7.87	9.23	9.12	10.60	13.89	15.04	**10.96**
Means (A)	**11.66**	**13.55**	**13.17**	**15.25**	**17.70**	**19.55**	
L.S.D. at 5 %	**For (S)= 0.21**		**For (A)= 0.22**		**For (S×A)= 0.40**		
	2019/2020 season						
Control	12.86	19.32	18.91	21.17	23.15	25.54	**20.16**
1000	11.66	14.80	14.24	17.22	18.40	20.12	**16.07**
2000	6.67	9.53	10.00	12.88	13.48	16.26	**11.47**
Means (A)	**10.40**	**14.55**	**14.38**	**17.09**	**18.34**	**20.64**	
L.S.D. at 5 %	**For (S)= 0.30**		**For (A)= 0.21**		**For (S×A)= 0.45**		

Table-5. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on salt resistance index (%) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	100.00	106.48	102.54	109.60	113.02	124.67	**109.38**
1000	83.43	92.86	92.72	99.16	104.51	111.92	**97.43**
2000	61.60	65.27	65.08	73.01	82.65	89.17	**72.79**
Means (A)	**81.68**	**88.20**	**86.78**	**93.92**	**100.06**	**108.59**	
L.S.D. at 5 %	**For (S)= 0.88**		**For (A)= 1.31**		**For (S×A)= 2.24**		
	2019/2020 season						
Control	100.00	114.45	112.45	118.31	123.79	134.15	**117.19**
1000	84.34	102.91	102.26	107.90	111.64	117.99	**104.51**
2000	59.42	67.74	69.23	79.69	85.56	97.89	**76.59**
Means (A)	**81.25**	**95.03**	**94.65**	**101.97**	**107.00**	**116.68**	
L.S.D. at 5 %	**For (S)= 0.67**		**For (A)= 0.87**		**For (S×A)= 1.52**		

2. Salt resistance index and chemical constituents

It is quite clear from the data in Tables5, 6 and 7 that, salt resistance index percentage(SRI%) and total carbohydrates percentage as well as total chlorophyll content and proline content of common sage significantly varied in response to soil salinity levels. However, salt resistance index and total carbohydrates percentages as well as total chlorophyll content was significantly decreased with 1000 and 2000 ppm levels of soil salinity compared with control in both seasons. In other words, the decreases in SRI% were about 10.93 and 10.82 % for the salinity level at 1000 ppm with significant difference between this treatments and control (un-salinized plants) in the first and second seasons, respectively. Also, the decrease in total chlorophyll content (SPAD) was about 14.10 and 14.44 % in the 1stand 2ndseasons, respectively. However, proline content of sage leaves was increased compared to control in the two seasons, as a result of soil salinity treatments (Table 8). *Salvia officinalis* salt resistance index ,total carbohydrates percentage as well as total chlorophyll and proline contents were significantly increased by utilizing salicylic and humic acids concentrations compared to control in both seasons. Also, salt resistance index (%) was increased as the utilized of salicylic, humic and salicylic + humic acids, respectively, in most cases (Table

Table 6. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on total carbohydrates percentage of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	14.24	14.61	14.55	15.66	17.52	18.31	**15.82**
1000	13.06	13.64	13.50	14.36	16.05	16.73	**14.56**
2000	11.76	11.98	11.98	12.01	13.50	13.59	**12.47**
Means (A)	**13.02**	**13.41**	**13.34**	**14.01**	**15.69**	**16.21**	
L.S.D. at 5 %	**For (S)= 0.34**		**For (A)= 0.34**		**For (S×A)= 0.63**		
	2019/2020 season						
Control	13.94	14.25	14.29	16.05	17.53	19.70	**15.79**
1000	12.38	13.15	13.24	15.02	15.82	16.82	**14.41**
2000	11.52	12.02	12.06	12.19	13.69	13.85	**12.56**
Means (A)	**12.61**	**13.14**	**13.19**	**14.42**	**15.68**	**16.46**	
L.S.D. at 5 %	**For (S)= 0.07**		**For (A)= 0.13**		**For (S×A)= 0.22**		

Table 7. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on total chlorophyll content (SPAD) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	50.40	51.83	53.52	54.71	55.43	57.44	**53.89**
1000	46.75	49.25	49.12	49.57	50.58	55.23	**50.08**
2000	43.64	44.45	45.12	46.50	48.30	49.69	**46.29**
Means (A)	**46.93**	**48.51**	**49.26**	**50.26**	**51.44**	**54.12**	
L.S.D. at 5 %	**For (S)= 0.23**		**For (A)= 0.36**		**For (S×A)= 0.61**		
	2019/2020 season						
Control	48.84	50.78	50.44	55.62	56.69	58.80	**53.53**
1000	47.08	48.10	46.92	52.22	53.17	54.77	**50.38**
2000	41.71	42.69	43.32	46.32	50.37	50.39	**45.80**
Means (A)	**45.88**	**47.19**	**46.89**	**51.39**	**53.41**	**54.65**	
L.S.D. at 5 %	**For (S)= 0.57**		**For (A)= 0.41**		**For (S×A)= 0.86**		

5). All SA and HA acids concentrations significantly increased chemical constituents of common sage leaves compared to control in the both seasons. Moreover, total chlorophyll content significantly increased with 200 ppm of SA + 1500 ppm of HA compared to control in the two seasons (Table 7).

Salt resistance index (%) of *Salvia officinalis* was increased as a result of the treatments of different acids (salicylic + humic) combined with most of salinity levels compared to un-salinized plants or those of the used salinity ones in the two seasons. Also, combination treatments between SA and HA acids and soil salinity significantly affect the common sagetotal carbohydrates, total chlorophyll content. Although, there was significant decrease, in this regard, due to spraying the sage plants with SA at 200 ppm + HA at 1500 ppm and were exposing to soil salinity at 0.0 and 1000 ppm.

3. Volatile oil production

Data given in Tables9 and10reveal that, utilizing all soil salinity level treatments(1000 and 2000 ppm) significantly increased volatile oil percentage of common

Table 8. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on proline content (mg/g as dry weight) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	3.67	3.60	3.50	3.33	3.43	3.23	**3.46**
1000	3.90	4.13	4.63	5.20	5.37	5.67	**4.82**
2000	4.33	4.83	4.97	5.97	5.73	6.70	**5.42**
Means (A)	**3.97**	**4.19**	**4.37**	**4.83**	**4.84**	**5.20**	
L.S.D. at 5 %	**For (S)= 0.09**		**For (A)= 0.10**		**For (S×A)= 0.20**		
	2019/2020 season						
Control	4.03	3.70	3.67	3.60	3.80	3.77	**3.76**
1000	3.77	4.07	5.13	5.40	5.67	5.87	**4.98**
2000	4.57	4.87	5.27	5.77	6.10	6.93	**5.58**
Means (A)	**4.12**	**4.21**	**4.69**	**4.92**	**5.19**	**5.52**	
L.S.D. at 5 %	**For (S)= 0.18**		**For (A)= 0.21**		**For (S×A)= 0.38**		

Table 9. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on volatile oil percentage of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	0.433	0.463	0.473	0.517	0.487	0.540	**0.486**
1000	0.457	0.470	0.527	0.537	0.567	0.583	**0.523**
2000	0.487	0.567	0.587	0.613	0.607	0.627	**0.581**
Means (A)	**0.459**	**0.500**	**0.529**	**0.556**	**0.553**	**0.583**	
L.S.D. at 5 %	**For (S)= 0.014**		**For (A)= 0.009**		**For (S×A)= 0.019**		
	2019/2020 season						
Control	0.453	0.473	0.513	0.547	0.523	0.567	**0.513**
1000	0.463	0.503	0.540	0.563	0.597	0.623	**0.548**
2000	0.477	0.540	0.477	0.613	0.637	0.633	**0.579**
Means (A)	**0.464**	**0.506**	**0.543**	**0.574**	**0.586**	**0.608**	
L.S.D. at 5 %	**For (S)= 0.003**		**For (A)= 0.007**		**For (S×A)= 0.012**		

sage compared to control (un-salinized plants) in both seasons. In contrast, volatile oil yield per sage plant (ml) significantly decreased when plants are exposed to soil salinity compared to control (sprayed with distilled water) in the first and second seasons. Using all salicylic acid (SA) and humic acid (HA) alone or in combinations treatments significantly increased volatile oil (%) and volatile oil yield per plant (ml) compared to control (unsprayed plants) in both seasons. The highest values in volatile oil production of common sage (*Salvia officinalis*) plants were obtained from 200 ppm SA+ 1500 ppm HA compared to control and the other ones under study during the two consecutive seasons. In general, all combination between soil salinity levels (1000 and 2000 ppm) and SA or/and HA concentrations treatments significantly decreased common sage volatile oil percentage and volatile oil yield per plant in both seasons. The control plants (without salinity application) which sprayed with SA at 200 ppm+ HAat 1500 ppm resulted in the highest values in this regard in both seasons, followed by the combination treatment between that plants which sprayed with Sa at 200 ppm+HAat 750 ppm.

Discussion

Abiotic environmental stresses essentially salinity and drought has the most effectiveness on aromatic and medicinal plants (Heidari *et al*., 2008). Salinity stress is one of the extreme harmful abiotic stress factors that impact the development, growth, productivity and

Table 10. Effect of soil salinity (S) and salicylic and humic acids (A) concentrations as well as their combinations (S×A) on volatile oil yield per plant (g) of *Salvia officinalis* plant during 2018/2019 and 2019/2020 seasons

Soil salinity levels (ppm)	Salicylic acid (SA) and humic acid (HA) concentrations (ppm)						Means (S)
	Control	200 SA	750 HA	1500 HA	200 SA+750 HA	200 SA+150 HA	
	2018/2019 season						
Control	0.626	0.793	0.783	0.999	1.029	1.298	**0.922**
1000	0.577	0.671	0.728	0.849	1.024	1.141	**0.832**
2000	0.383	0.523	0.535	0.650	0.842	0.943	**0.646**
Means (A)	**0.529**	**0.662**	**0.682**	**0.833**	**0.965**	**1.127**	
L.S.D. at 5 %	**For (S)= 0.016**		**For (A)= 0.016**		**For (S×A)= 0.029**		
	2019/2020 season						
Control	0.583	0.915	0.971	1.157	1.212	1.447	**1.047**
1000	0.540	0.745	0.769	0.970	1.098	1.254	**0.896**
2000	0.318	0.515	0.577	0.790	0.859	1.030	**0.681**
Means (A)	**0.480**	**0.724**	**0.772**	**0.972**	**1.056**	**1.244**	
L.S.D. at 5 %	**For (S)= 0.019**		**For (A)= 0.017**		**For (S×A)= 0.032**		

physiology of plants. The various results were devoted from the influence of salinity stress on the quantitative and qualitative parameters. For example, it was reported that increasing of salinity stress reduced almost all of yield and essential oil in *Deracocephalum moldavica* (Safikhani *et al*., 2007), some volatile oil in *Matricaria chamomila* (Razmjoo *et al*., 2008). Yield components volatile oil, salt resistance index and chemical constituents were notice to be repressed under salt stress in *Salvia officinalis*, *Ocimum basilicum*, *Coleus* species, cluster bean, sweet basil and *Rosmarinus officinalis* (Ben Taarit *et al*., 2009; Said-Al Ahl *et al*., 2010; Kotagiri and Kolluru, 2017; Nassar *et al*., 2018; Ibrahim *et al*., 2019; Abdelkader *et al*., 2019).

Also, due to the effect of salicylic acid or humic acid and salicylicacid + humic acid, which penetrate rapidly into the plant tissues through the stomata and play vital roles in biological and physiological processes of *Salvia officinalis* which reflected on the more yielded plants. Furthermore, Safaei *et al*., (2014) pointed out that different rates of humic acid imposed a significant effect on seed weight, seed yield and biological of black cumin plants compared to control. Also, Mohammed *et al*., (2019) found that the maximum values of herb dry weight/plant and air-dry weight of flower heads/plant were noticed when chamomile plants were applied with the highest rate of humic acid.

Moreover, as mentioned above, both salicylic acid and humic acid increased growth parameters of common sage (*Salvia officinalis*, L.) plant, in turn; they together under soil salinity conditions might maximize their influences leading to heaviest herb yield per plant. These results are in line with those stated by Esringü *et al*., (2015) on *Impatiens walleriana* and Es-sbihi *et al*., (2016) on *Mentha suaveolens* plants. There is a correlation between the beneficial effect of SA on the synthesis of secondary metabolites with advance in growth, photosynthesis and nutrient content (Khanam and Mohammad, 2018). These results also found by Es-sbihi *et al.,* (2020) who reported that SA spraying on sage plants significantly increased stem and root growth. Furthermore, The positive influences of Humic Acid on cell membrane functions by elevating nutrient uptake, respiration, biosynthesis of ion absorption, nucleic acid, enzyme in order to they are hormone-like materials (Yang *et al*., 2004). HA used for plant nutrition, enhance development, root and plant growth as well as yield due to its action on physiological and metabolic procedures (Eyheraguibel *et al*., 2008). Moreover, Said-Al Ahl *et al*., (2016) reported that spraying by HArecorded the best results of plant height, number of branches and seed yield compared to control. These results are in harmony with those reported by Abou El-Yazied (2011) on *Capsicum annuum*, Pacheco *et al*., (2013) on *Calendula officinalis* and Karalijaand Parić (2017) on *Ocimum basilicum* plants regarding salicylic acid effect as well as Saadati and Baghi (2014) on *Cicer arietinum* plant, regarding humic acid effect.

Furthermore, Khalil *et al*., (2019) stated that the highest yield of *Thymus vulgaris* was obtained from drought stressed plants (25% FC) sprayed with 2 mM SA. In addition, Desoky *et al*., (2019) reported that application of humus component overcome the harmful influences of salinity stress on the of shoot fresh and dry weight Sudan grass compared with untreated plants. Moreover, salicylic acid and humic acid are a well-known biostimulant which has positive effects on plant growth and significantly mitigates the injuries caused by abiotic stresses (Jafari *et al*., 2008). Who reported that foliar by salicylic acid and ascorbic acid via increasing total chlorophyll content and also decreased electrolyte leakage caused moderate the adverse impacts of salinity stress on the safflower. In connection with the photosynthetic contents of *Medicago sativa*, the humic acid showed positive influences, especially in terms of 2 and 12 dS m^{-1} salinity levels, respectively (Sofi *et al*., 2018).

CONCLUSION

From above mentioned results, it is preferable to spray common sage (*Salvia officinalis*, L.) plants with salicylic acid at 200 ppm + humic acid at 1500 ppm four times/ season under moderate soil salt stress (1000 ppm) to improve the yield components, salt resistance index, total chlorophyll content and volatile oil production of salvia plants.

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