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EFFECT OF FOLIAR SPRAY WITH ASCORBIC AND SALICYLIC ACIDS ON GROWTH, YIELD, SALT TOLERALNCE TRAIT AND TOTAL CHLOROPHYLL OF LAVENDER (*Lavandula officinalis*, Chiax) UNDER SALINE STRESS CONDITIONS

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ABSTRACT: A greenhouse pot experiment was conducted at the Nursery of Ornamental Plants, Horticulture Department, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt during the two winter consecutive seasons of 2018/2019 and 2019/2020 to study the effect of different soil salinity levels (0.0, 1000, 2000 and 3000 ppm), foliar spray with 150 ppm of salicylic acid (SA), 250 ppm of ascorbic acid (AA), and 150 ppm SA+250 ppm AA as well as control (spraying with water) and their combination treatments on growth, herb yield per plant, salt tolerance trait percentage and total chlorophyll content (SPAD unit) of lavender plants. The investigations were performed in a split-plot in complete randomized block design with 3 replications. The obtained results cleared that using soil salinity at high levels (2000 and 3000 ppm) decreased growth parameters (plant height, number of branches /plant, root length, root number per plant, fresh and dry weights of roots/ plant), yield components (fresh and dry weights of herb yield/ plant) and total chlorophyll content compared to control. But, the low level one (1000 ppm) showed significant increase in lavender growth and yield as well as it enhanced salt tolerance index compared to un-salinized plants and the other levels under study. Moreover, the highest values in abovementioned parameters were registered by the combination treatment between 150 ppm SA and 250 ppm AA acids in both seasons. Generally, it could conclude that 150 ppm SA + 250 ppm AA, showed a uniform impact in alleviating of lavender growth inhibition and its productivity under low salinity stress condition with increasing in salt resistance (%).

Key words: *Lavandula officinalis*, salinity, salicylic acid, ascorbic acid, growth, yield, chlorophyll.

INTRODUCTION

Lavender (*Lavandula officinalis*, Chaix), an important multidisciplinary aromatic plant with major utilize in fragrance, pharmaceutical and food industries and for aromatic garden design belongs to Nepetoideae subfamily of Lamiaceae (**Hassanpouraghdam *et al.*, 2011**). Moreover, **Upson and Andrews (2004)** pointed out that lavender plant is a native of the Mediterranean region. Pharmaceutically, lavender plant and its preparations have long been used as anti-convulscent, in cold and flu treatment, diuretic, digestive, sedative and perspiration stimulant as well as for treatment of anxiety and sadness (**Omidbaigi, 2004; Afsharypuor and Azarbayjany, 2006**).

Salinity is one of the essential a biotic factors negatively impacting plant growth and yield all over the world (**Koca *et al.*, 2007**). Rising salt levels in soil reduces the plant capability to harmfully influences metabolic processes, absorbs water and influences nutrient absorbance, equipoise of conductance of stomata, osmotic, hydraulic conductivity, net photosynthetic rate, and intercellular CO_2 concentrations, all of these effects in negatively affecting the plant intensity to develop and grow (**Al-Karaki *et al.*, 2001**). The higher rates of toxic ions like Na^+ and Cl^- disadvantage the balance between ions through

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decreasins the plant capability to take in other ions like K^+, Ca^{2+} and Mn^{2+} (**Hasegawa *et al*., 2000**).

Salicylic acid (SA) is plant growth regulator and a natural phenolic compound that functions a key role in the regulation of plant development and growth (**Rivas- San Vicente and Plasencia 2011**). Previous studies have revealed some turns of SA in biotic stresses *via* creation of systemic acquired opposition. In increment to its role in biotic stress answers, SA also takes in modulating the plant reply to many abiotic stresses, including salinity (**Rady and Mohamed, 2015**). Ascorbic acid (AA) is an antioxidant and, in combination with other compositions of the antioxidant system, saves plants from oxidative injury resulting from photosynthesis, aerobic metabolism and a range of pollutants like heavy metal and saline stress (**Mazid *et al*., 2011**). The positive role of AA in enhancing herb dry weight and yield were noticed by several investigators such as **Ghahory (2012)** on *Nigella sativa*; A**bdelkader and Hamad (2014)** on *Hibiscus sabdariffa*; and **Hashem and Hegab (2018)** on *Lavandula pubescens*.

Therefore, the main goal of this work was to evaluate the role of salicylic and ascorbic acids on counteracting the deleterious effect of soil salinity on growth parameters, yield components, salt resistance percentage and total chlorophyll content of lavender plant.

MATERIALS AND METHODS

Two pot experiments in greenhouse was conducted during the two winter consecutive seasons of 2018/2019 and 2019/2020 at the Nursery of Ornamental Plants, Horticulture Department, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt. This work was carried out to examine the effect of soil salinity levels (0.0, 1000, 2000 and 3000 ppm), foliar spray with 150 ppm salicylic acid (SA), 250 ppm ascorbic acid (AA), and 150 ppm SA + 250 ppm AA as well as control (spraying with water) and their combination treatments on growth, yield, salt resistance percentage and total chlorophyll content of lavender plants. However, lavender plants were foliar sprayed with SA and AA four times at 30, 45, 60 and 75 days after planting. The source of salicylic acid ($C_7H_6O_3$) and ascorbic acid ($C_6H_8O_6$) were Techno Gene Company (TGC), Dokky, Giza, Egypt.

Seedlings of lavender (*Lavandula officinalis*, Chaix) were obtained from a private nursery in Belbeis District (called Mostafa Aboesa Nursery), Sharkia Governorate, Egypt and were planted in pots 40 cm filled with about 8 kg soil with mixture of clay and sand (1/1, *V/V*), on 1st October during both seasons. The clay soil for the experiment was collected from the upper layer (0-15 cm) of a cultivated field. The collected soil was air-dried, crushed and sieved through a 2 mm sieve and homogeneously mixed before subjecting to different treatment. The physical and chemical properties of the used soil mixture are shown in Table 1 according to **Chapman and Pratt (1978)**.

Response of lavender plants to different levels of salinity was evaluated under pots culture conditions. Four levels of artificial soil salinity were used 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.

All seedlings were similar in growth and 12 cm in length. Two seedlings were planted per pot. The plot contained about 64 pots; three plants from each replication were randomly selected for observing growth parameters, herb yield and total chlorophyll content of lavender. The mean value of each parameter was computed from 9 plants (3 plants from each replication).

The basal doses 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, single superphosphate and potassium sulphate, respectively, at 40, 55 and 70 days of planting date. The statistical layout of this experiment was a split-plot design experiment between salinity level (four levels) as main plot and acids (four concentrations) as sub-plot in randomized complete blocks design (RCBD) with three replicates. The combination treatments between soil salinity level and acids concentrations were consisted of 16 treatments. All recommended agricultural practices of growing lavender plants were done whenever needed.

Table 1. Physical and chemical properties of the used soil mixture (average of two seasons)

Physical analysis														Soil texture	
Clay (%)			Silt (%)						Sand (%)					Sandy	
22.87			8.43						68.70						
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	**7.70**	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

Data Recorded

Growth parameters

Three plants were randomly chosen at 88 days after planting from each experimental unit in the two seasons and the following date were record: Plant height (cm), number of branches, root length (cm), root number per plant, fresh and dry weights of roots/ plant (g).

Yield components

Fresh and dry herb (branches + leaves) yield (dried in oven at 45ºC) per plant were determined after 120 days after planting in both seasons. The salt tolerance trait index (STTI %), as a real indicator for salinity tolerance was calculated from the equation mentioned before by **Chen *et al*. (2007)** on Asparagus bean: SRI (%) = Mean fresh herb yield per plant of the salt treated plants/mean fresh herb yield per plant of control one × 100.

Total chlorophyll

In fresh leaf samples of existing lavender plants after 95 days after planting date during both seasons, total chlorophyll content (SPAD unit) were measured by using SPAD- 502 meter as described by **Markwell *et al*. (1995)**.

Statistical Analysis

Data of the present work were statically analyzed and the differences between the means of the treatments (salinity levels and acids concentrations) were considered significant when they were more than the least significant differences (LSD) at the 5% levels by using computer program of Statistix Version 9 (**Analytical Software, 2008**).

RESULTS

Growth Parameters

Plant height (cm)

Results in Table 3 show that, using salinity treatments at high levels (2000 and 3000 ppm) significantly decreased plant height of lavender compared to control and the lowest level (1000 ppm) in both seasons. Generally, lavender plant height was decreased with increasing salinity level to reach its minimum by using

Table 3. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on plant height (cm) of *Lavandula officinalis* plant at 88 days after planting during 2018/2019 and 2019/ 2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	43.55	34.33	51.89	52.78	**45.64**
1000	48.89	53.78	54.78	56.78	**53.56**
2000	35.11	36.89	37.44	43.11	**38.14**
3000	28.44	32.67	33.34	36.67	**32.78**
Mean (A)	**39.00**	**39.42**	**44.36**	**47.33**	
LSD at 5%	**For (S)= 6.34**		**For (A)= 5.33**	**For (S×A)= 11.27**	
			2019/2020 season		
Control	45.89	51.11	53.22	55.22	**51.36**
1000	50.89	55.78	57.44	60.00	**56.03**
2000	36.78	41.89	41.89	45.89	**41.61**
3000	27.22	31.33	32.66	36.22	**31.86**
Mean (A)	**40.20**	**45.03**	**46.31**	**49.33**	
LSD at 5%	**For (S)= 1.42**		**For (A)= 0.76**	**For (S×A)= 1.93**	

that of 3000 ppm. Furthermore, in most cases, salicylic and ascorbic acids treatments significantly increased lavender plant height compared to untreated plants in the two consecutive seasons. The combination treatment between SA and AA acids at 150 and 250 ppm, respectively significantly increased plant height compared to control and the other ones under study, in most cases. In addition, the combination between salinity and SA + AA acids decreased plant height comparing to control (except that of 1000 ppm soil salinity plus SA + AA acids).

Number of branches per plant

Results listed in Table 4 indicate that, the highest value in branch number per plant was noticed with the treatment of 1000 ppm with significant differences over control and the other two ones levels under study. In general, soil salinity treatments (2000 and 3000 ppm) reduced number of branches per plant compared to control during both seasons. Moreover, the branch number per lavender plant was decreased as the salinity levels increased up to 3000 ppm, which showed the lowest number. Salicylic and ascorbic acids treatments significantly increased number of branches per lavender plant compared to control in the two seasons. Number of branches per plant has recorded the highest value when lavender plants treated by 150 ppm SA + 250 ppm AA in the first and second seasons. Using ascorbic acid at 250 ppm alone or in combination with 150 ppm salicylic acid under all salinity levels, significantly increased number of branches per lavender plant as compared to salinity treatments alone.

Root length (cm)

The results described in Table 5 pointed out that, using soil salinity treatments significantly decreased lavender root length (except that of 1000 ppm) compared to control in both seasons. However, salicylic acid and ascorbic acid each

Table 4. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on number of branches/plant of *Lavandula officinalis* plant at 88 days after planting during 2018/ 2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	22.78	25.22	26.00	27.00	**25.25**
1000	24.89	26.89	28.78	30.89	**27.86**
2000	16.55	18.11	18.78	22.78	**19.05**
3000	12.33	14.56	14.89	17.89	**14.92**
Mean (A)	**19.14**	**21.20**	**22.11**	**24.64**	
LSD at 5%	**For (S)= 0.56**		**For (A)= 0.45**	**For (S×A)= 0.95**	
			2019/2020 season		
Control	21.56	26.11	27.56	29.33	**26.14**
1000	23.89	28.55	30.44	32.89	**28.94**
2000	19.45	23.22	22.44	24.78	**22.47**
3000	11.78	14.44	13.89	15.78	**13.97**
Mean (A)	**19.17**	**23.08**	**23.58**	**25.69**	
LSD at 5%	**For (S)= 0.69**		**For (A)= 0.48**	**For (S×A)= 1.07**	

Table 5. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on root length (cm) of *Lavandula officinalis* plant at 88 days after planting during 2018/2019 and 2019/ 2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	22.67	23.67	26.67	26.33	**24.83**
1000	25.00	27.67	29.67	29.33	**27.92**
2000	16.00	19.11	19.34	22.55	**19.25**
3000	14.11	16.33	17.11	19.11	**16.67**
Mean (A)	**19.44**	**21.69**	**23.20**	**24.33**	
LSD at 5%	**For (S)= 0.57**		**For (A)= 0.45**	**For (S×A)= 0.96**	
			2019/2020 season		
Control	22.67	24.33	28.33	29.33	**26.17**
1000	24.33	26.67	28.67	31.67	**27.83**
2000	17.44	20.11	20.77	23.67	**20.50**
3000	13.00	14.89	15.22	18.22	**15.33**
Mean (A)	**19.36**	**21.50**	**23.25**	**25.72**	
LSD at 5%	**For (S)= 0.62**		**For (A)= 0.49**	**For (S×A)= 1.06**	

alone or in combination significantly increased root length compared to control in the both seasons. Also, the best combination treatment was 1000 ppm of salinity and 150 ppm SA + 250 ppm AA in comparison with the other combinations between salinity levels and acid concentrations under study in both seasons. Furthermore, under each of acid concentration root length of lavender was decreased as salinity increased from 2000 to 3000 ppm in both seasons.

Number of roots per plant

It is quite clear from the results in Table 6 that, the highest levels of soil salinity significantly decreased root number per plant in the first and second seasons. Also, number of roots per lavender plant was increased up to 7.89 and 5.13% when plants were exposed to soil salinity with 1000 ppm compared to control in the first and second seasons, respectively. SA and AA acids treatments significantly increased lavender root number compared to untreated plants in both seasons. SA at 150 ppm plus AA at 250 ppm significantly increased number of roots per plant compared to control and the other ones under study. In the same time, the combination treatment between soil salinity at 1000 ppm and 150 ppm SA + 250 ppm AA was more effective in root number per plant than the other treatments of salinity or SA and AA acids each alone in 2018/2019 and 2019/2020 seasons.

Fresh weight of roots per plant (g)

The results tabulated in Table 7 reveal that, all soil salinity treatments (except that of 1000 ppm level) showed significant decrease in lavender fresh weight of roots per plant comparing to control in both seasons. Moreover, as the salinity levels increased up to 3000 ppm, the fresh weight of roots was reduced. However, the concentration of SA at 150 ppm + AA at 250 ppm significantly increased fresh weight of roots per lavender plant compared to control (without acids spraying) in the first and second seasons. In addition, the fresh weight of roots per plant was increased as a result of the combination treatments between soil salinity levels (1000 and 2000 ppm) and SA, AA or SA+AA acids compared to that of combination treatments between soil salinity at 3000 ppm level and SA and AA acids alone or in combination.

Dry weight of roots per plant (g)

As shown in Table 8 that, soil salinity treatments (except that of 1000 ppm) showed significant decrease in *Lavandula officinalis* dry weight of roots per plant comparing to control during the two seasons. Generally, as the salinity level increased up to 3000 ppm, the dry weight of roots was decreased. Moreover, the concentration of 150 ppm SA + 250 ppm AA recorded a significant increase in dry weight of roots per plant compared to control in both seasons. The increases in this regard were about 50.74 and 77.00% for AS at 150 pm + AA at 250 ppm compared to control in the first and second seasons, respectively. Generally, the dry weight of lavender roots/plant recorded more/or less similar trend as mentioned in fresh weight of roots/plant as a result of combination treatments between soil salinity and SA as well as AA acids.

Yield Components and Salt Tolerance Trait Index

Herb fresh weight per plant (g)

Results under discussion in Table 9 indicate that, soil salinity treatments at 2000 and 3000 ppm decreased lavender herb fresh weight per plant compared to control in both seasons. Whenever, the increases in fresh weight of herb per plant were about 6.24 and 4.49 % for the salinity level at 1000 ppm compared to control in the first and second seasons, respectively. Salicylic acid at 150 ppm + ascorbic acid at 250 ppm significantly increased fresh weight of herb per lavender plant compared to control and the other ones under study during both seasons. Furthermore, using 150 ppm SA + 250 ppm AA under all soil salinity levels significantly increased fresh weight of herb per plant as compared to salinity treatments alone in both seasons. In the same time, the combination treatment between salinity at 1000 ppm and 150 ppm SA + 250 ppm AA was more effective in fresh weight of herb per lavender plant values than the other treatments of salinity or acids each alone during the two seasons.

Herb dry weight per plant (g)

From results presented in Table 10 it is obvious that, using soil salinity level treatments (except 1000 ppm level) decreased herb dry weight per plant of lavender compared to control in both seasons. Such decrease was significant by using the level of 3000 ppm. Salicylic acid and ascorbic

Table 6. Effect of soil salinity (S) and acids (A) concentrations as well as their combinations (S×A) on number of roots/plant of *Lavandula officinalis* plant at 88 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	17.11	18.89	20.44	22.11	**19.64**
1000	18.78	20.44	21.67	23.89	**21.19**
2000	13.22	15.56	15.89	18.11	**15.70**
3000	9.78	12.55	13.00	14.22	**12.39**
Mean (A)	**14.72**	**16.86**	**17.75**	**19.58**	
LSD at 5%	**For (S)= 0.18**		**For (A)= 0.30**	**For (S×A)= 0.55**	
			2019/2020 season		
Control	17.89	19.67	24.11	24.89	**21.64**
1000	19.44	22.44	23.44	25.67	**22.75**
2000	14.00	17.56	16.89	19.22	**16.92**
3000	10.56	13.22	13.22	14.45	**12.86**
Mean (A)	**15.47**	**18.22**	**19.42**	**21.06**	
LSD at 5%	**For (S)= 0.25**		**For (A)= 0.40**	**For (S×A)= 0.73**	

Table 7. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on fresh weight of roots/plant (g) of *Lavandula officinalis* plant at 88 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	13.61	14.02	14.38	15.93	**14.49**
1000	14.14	14.93	15.93	17.77	**15.69**
2000	9.81	11.77	11.80	13.11	**11.62**
3000	6.69	7.24	7.87	9.61	**7.85**
Mean (A)	**11.06**	**11.99**	**12.50**	**14.10**	
LSD at 5%	**For (S)= 0.29**		**For (A)= 0.22**	**For (S×A)= 0.47**	
			2019/2020 season		
Control	13.29	15.44	15.74	19.08	**15.89**
1000	13.70	15.62	16.11	20.00	**16.36**
2000	10.26	12.67	12.67	14.42	**12.51**
3000	7.38	7.54	7.71	10.17	**8.20**
Mean (A)	**11.16**	**12.82**	**13.06**	**15.92**	
LSD at 5%	**For (S)= 0.22**		**For (A)= 0.17**	**For (S×A)= 0.37**	

Table 8. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on dry weight of roots/plant (g) of *Lavandula officinalis* plant at 88 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	5.28	5.45	5.48	6.74	**5.74**
1000	5.44	6.19	7.24	8.57	**6.86**
2000	4.03	4.39	4.57	5.68	**4.67**
3000	1.58	2.06	2.17	3.62	**2.36**
Mean (A)	**4.08**	**4.52**	**4.87**	**6.15**	
LSD at 5%	**For (S)= 0.14**		**For (A)= 0.15**	**For (S×A)= 0.29**	
			2019/2020 season		
Control	5.19	6.10	6.75	8.76	**6.70**
1000	5.34	6.69	7.40	9.33	**7.19**
2000	4.13	5.79	5.62	7.01	**5.64**
3000	1.86	2.16	2.26	4.14	**2.61**
Mean (A)	**4.13**	**5.19**	**5.51**	**7.31**	
LSD at 5%	**For (S)= 0.12**		**For (A)= 0.09**	**For (S×A)= 0.20**	

Table 9. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on fresh weight of herb/plant (g) of *Lavandula officinalis* plant at 120 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	72.59	76.33	77.16	80.18	**76.56**
1000	76.42	79.43	82.79	86.72	**81.34**
2000	55.89	60.86	61.10	69.27	**61.78**
3000	42.34	48.66	48.65	54.37	**48.51**
Mean (A)	**61.81**	**66.32**	**67.43**	**72.63**	
LSD at 5%	**For (S)= 0.40**		**For (A)= 0.49**	**For (S×A)= 0.94**	
			2019/2020 season		
Control	72.53	74.20	76.81	81.44	**76.24**
1000	72.78	76.00	81.72	88.17	**79.66**
2000	58.29	63.56	62.76	72.62	**64.31**
3000	40.42	50.91	50.65	55.05	**49.26**
Mean (A)	**61.00**	**66.17**	**67.98**	**74.32**	
LSD at 5%	**For (S)= 0.53**		**For (A)= 0.53**	**For (S×A)= 1.06**	

Table 10. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on dry weight of herb/plant (g) of *Lavandula officinalis* plant at 120 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	28.32	29.89	30.95	38.00	**31.79**
1000	31.14	35.13	39.39	40.78	**36.61**
2000	18.86	21.65	21.99	32.19	**23.67**
3000	13.33	15.88	16.16	18.51	**15.97**
Mean (A)	**22.91**	**25.64**	**27.12**	**32.37**	
LSD at 5%	For (S)= 0.30		For (A)= 0.31	For (S×A)= 0.61	
			2019/2020 season		
Control	28.14	29.96	31.13	39.23	**32.11**
1000	28.82	30.94	37.27	42.54	**34.89**
2000	19.41	22.65	22.28	33.97	**24.58**
3000	12.10	16.85	17.23	19.48	**16.42**
Mean (A)	**22.12**	**25.10**	**26.98**	**33.80**	
LSD at 5%	For (S)= 0.45		For (A)= 0.36	For (S×A)= 0.77	

acid alone or in combination significantly increased dry weight of herb per plant compared to control in the first and second seasons. Also, the highest dry weight of lavender herb per plant values was achieved by the combination treatment between the two acids compared to the other ones under study. Likewise, the combination treatment between salinity at 1000 ppm and 150 ppm SA + 250 ppm AA significantly increased fresh weight of herb per lavender plant compared to control in the two seasons. However, the increases in this regard were about 44.00 and 51.17% compared to control in the 1st and 2nd seasons, respectively.

Salt tolerance trait index (%)

Results recorded in Table 11 demonstrate that, salt tolerance trait index percentage was significantly decreased with 2000 and 3000 ppm levels of soil salinity compared with control in both seasons. In other words, the increases in this connection were about 12.05 and 9.84% for the salinity level at 1000 ppm, with significant difference between this treatments and control (un-salinized +unsprayed plants) in the 1st and 2nd seasons, respectively. *Lavandula officinalis* salt resistance index (%) was significantly increased by using salicylic and ascorbic acids alone or in combination compared to control in both seasons. In the same time, salt resistance index (%) of lavender was increased as a result of the treatments of 150 ppm SA + 250 ppm AA combined with most of salinity levels compared to the combination between acids and the highest levels of soil salinity in the two seasons.

Total chlorophyll content (SPAD unit)

The obtained results in Table 12 suggest that, there was a decrease in total chlorophyll content in the first season and second seasons by using the soil salinity levels of 2000 and 3000 ppm and an increase in this regard by using the level of 1000 ppm with significant differences between them. Total chlorophyll content (SPAD) was increased by using SA and AA as foliar spray compared to control in the two seasons. However, the highest values in this constant were achieved with 150 ppm SA + 250 ppm AA compared with control. Moreover, total chlorophyll content in lavender leaves was

Table 11. Effect of soil salinity (S) levels and acids (A) concentrations as well as their combinations (S×A) on salt resistance index (%) of *Lavandula officinalis* plant at 120 days after planting during 2018/2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	100.00	105.15	106.30	110.45	**105.48**
1000	105.27	109.42	114.05	119.46	**112.05**
2000	76.99	83.84	84.18	95.43	**85.11**
3000	58.33	67.03	67.03	74.90	**66.82**
Mean (A)	**85.15**	**91.36**	**92.89**	**100.06**	
LSD at 5%	**For (S)= 0.54**		**For (A)= 0.68**	**For (S×A)= 1.29**	
			2019/2020 season		
Control	100.00	102.31	105.90	112.30	**105.13**
1000	100.35	104.79	112.67	121.57	**109.84**
2000	80.37	87.63	86.53	100.13	**88.66**
3000	55.73	70.19	69.84	75.90	**67.91**
Mean (A)	**84.11**	**91.23**	**93.74**	**102.47**	
LSD at 5%	**For (S)= 0.81**		**For (A)= 0.74**	**For (S×A)= 1.50**	

Table 12. Effect of soil salinity (S) and acids (A) concentrations as well as their combinations (S×A) on total chlorophyll content (SPAD) of *Lavandula officinalis* plant at 95 days after planting during 2018/ 2019 and 2019/2020 seasons

Soil salinity (ppm)	Salicylic acid (SA) and ascorbic acid (AA) concentrations (ppm)				Mean (S)
	Control	150 SA	250 AA	150 SA+250 AA	
			2018/2019 season		
Control	45.11	46.22	45.89	46.00	**46.06**
1000	45.56	46.11	47.33	48.56	**46.89**
2000	42.11	42.78	42.89	44.67	**43.11**
3000	39.55	40.44	41.55	43.11	**41.17**
Mean (A)	**43.08**	**43.89**	**44.42**	**45.83**	
LSD at 5%	**For (S)= 0.66**		**For (A)= 0.37**	**For (S×A)= 0.92**	
			2019/2020 season		
Control	45.44	45.44	45.56	47.56	**46.00**
1000	45.67	46.00	46.22	48.22	**46.53**
2000	41.89	42.67	43.89	45.00	**43.36**
3000	39.89	40.67	40.44	42.56	**40.89**
Mean (A)	**43.22**	**43.69**	**44.03**	**45.83**	
LSD at 5%	**For (S)= 0.42**		**For (A)= 0.39**	**For (S×A)= 0.79**	

increased as a result of the treatment of salicylic acid at 150 ppm + ascorbic acid at 250 ppm combined to those of salinity at 1000 ppm in comparison to those of salinity alone (2000 and 3000 ppm) or those of the other ones of combination between acids and salinity in both seasons.

DISCUSSION

Effect of Soil Salinity on Growth, Yield and Total Chlorophyll

Consulting the above mentioned results which indicated that all applied salinity levels (especially 2000 and 3000 ppm levels) caused a decrease in growth parameters (plant height, number of branches per plant, root length, root number per plant as well as fresh and dry weights of roots per lavender plant), yield components (fresh and dry weights of herb per plant), Salt resistance index and total chlorophyll content compared with un-salinized plants. The harmful influences of soil salinity on plant development and growth are due to the inhibition of photosynthesis, the induction of growth controller, and reduction of leaf area (**Kashem *et al*., 2000**), leaf protein content (**Farouk *et al*., 2012**), and decreased ability to supply and use assimilates/photosynthates (**Kashem *et al*., 2000**). These results are in agreement with those obtained by **Khaliq *et al*. (2014)** on *Ocimum basilicum* and **Helaly *et al*. (2018)** on rosemary plant. In addition, **Shehata and Nosir (2019)** reported that under high levels of salinity (2000 and 4000 ppm NaCl), the sweet basil plants gave lowest values of plant height, shoot length and branch number/plant compared to control. Also, **Abdelkader *et al*. (2019)** on rosemary plant, indicated that using salinity levels (2000, 3000 and 4000 ppm) significantly decreased growth parameters (plant height, number of branches/plant), dry weight of herb/ plant, salt resistance index (%) and total chlorophyll content (SPAD) compared to control. **Ibrahim *et al*. (2019)** on sweet basil plant, showed a significant decrease in plant height, number of branches/plant and herb and root dry weight, salt resistance index and photosynthetic pigments (Chlorophyll a and chlorophyll b) with increasing the levels of salinity.

Effect of Salicylic and Ascorbic Acids on Growth, Yield and Total Chlorophyll

As the concentration of salicylic acid and ascorbic acid alone or in combination used, all the above mentioned parameters increased throughout the range examined. The advantages of utilizing on enhancing plant growth have been previously reported (**Abdelkader and Hamad, 2014**; **Soltani *et al*., 2014**; **Miri *et al*., 2015**; **Hashem**, **2018** and **Hassan *et al*., 2019**). It seems that salicylic and ascorbic acids by increasing the amount of total chlorophyll content (Table 12), caused more efficient in photosynthesis which ultimately leads to enhancing fresh and dry weights of herb and roots per lavender plants. This is consistent with the statement of **Rivas-San Vicente and Plasencia (2011)**, who suggested that the growth elevating influences of SA could be concerning to changes in the hormonal status or by perfection of photosynthesis, stomata conductance and transpiration. Also, **Blokhina *et al*. (2003)** pointed out that, ascorbic acid (AA) is the most abundant antioxidant which protect cell, ascorbic acid is currently considered to be a regulator on plant development and growth owing to its impact on cell division and differentiation which reflected in higher plant yield. However, **Abo-Marzoka *et al*. (2016)** suggested that ascorbic acid at 100 ppm plus salicylic acid 200 ppm could be a promising material utilized to decrease the harmful effect of water stress on the growth parameters and yield components of maize plants.

Effect of Combination Treatments between Salinity and Acids on Growth, Yield and Total Chlorophyll

However, some treatments of salicylic and ascorbic acids especially the combination treatment between them to some extent, decreased the deleterious effect of salinity in abovementioned parameters of lavender plant. Such influences might be due to promoting the metabolic processes (anabolism) leading to additional vegetative growth and yield components. Also, **Riaz *et al*. (2014)** on *Caralluma tuberculata* found that the salt stress decreased by applying ascorbic acid (AA) and salicylic acid (Sa) evidenced by normal enzyme level and recuperation of cellular structure. Furthermore, **Al-Mayahi (2016)** reported that maximum growth parameters and chlorophyll content of *Phoenix dactylifera* shoots was noticed after 75 days of culturing in the medium supplemented with 50 mgl^{-1} salicylic acid (SA) and 100 mgl^{-1} ascorbic acid (AA) in both salt stress and non-stress conditions. These results are in line with those reported by **Jafari *et al*. (2019)** on safflower plants. They reported that foliar application of 400 ppm AA and 0.5 and 1mM SA increased chlorophyll content.

Conclusion

From above mentioned results, it is preferable to spray lavender (*Lavandula officinalis*, Chaix) plants with salicylic acid at 150 ppm plus ascorbic acid at 250 ppm four times/season under low soil salt stress (1000 ppm) to enhance the growth parameters, yield components and total chlorophyll content of lavender plant.

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تأثير الرش الورقي بأحماض الساليسيليك والأسكوربيك على النمو والمحصول ونسبة تحمل الملوحة والكلوروفيل الكلي لنبات اللافندر تحت ظروف الإجهاد الملحي

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أُجريت تجربة أصص في البيوت المحمية بمشتل نباتات الزينة بقسم البساتين - كلية الزراعة - جامعة الزقازيق بمحافظة الشرقية، مصر خلال موسمي الشتاء المتتاليين ٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩ لدراسة تأثير مستويات ملوحة التربة المختلفة (صفر، ١٠٠٠، ٢٠٠٠ و٣٠٠٠ جزء في المليون)، والرش الورقي بـ ١٥٠ جزء في المليون من حمض الساليسيليك و ٢٥٠ جزء في المليون من حمض الأسكوربيك، و١٥٠ جزء في المليون من حمض الساليسيليك + ٢٥٠ جزء في المليون من حمض الأسكوربيك بجانب الكنترول (الرش بالماء) ومعاملات التداخل بينهما على النمو، محصول العشب لكل نبات، دليل مقاومة الملوحة والكلوروفيل الكلي (وحدة سباد) لنباتات اللافندر، وقد أجريت التجارب في تصميم القطاعات المنشقة مرة واحدة في تصميم قطاعات كاملة العشوائية في ٣ مكررات، أوضحت النتائج المتحصل عليها أن استخدام المستويات العالية من الملوحة (٢٠٠٠ و٣٠٠٠ جزء في مليون) أدى إلى نقص صفات النمو (ارتفاع النبات، عدد الأفرع/النبات، طول الجذر، عدد الجذور لكل نبات، الأوزان الطازجة والجافة للجذور/النبات)، المساهمات المحصولية (الأوزان الطازجة والجافة لمحصول العشب/النبات) والمحتوى الكلي من الكلوروفيل مقارنة بالكنترول (الرش بالماء)، ولكن، استخدام المستوى المنخفض من الملوحة (١٠٠٠ جزء في المليون) أدى إلى زيادة معنوية في صفات النمو ومحصول العشب وحسَّن من دليل مقاومة الملوحة مقارنة بالنباتات غير المعرضة للملوحة والمستويات الأخرى تحت الدراسة. علاوة على ذلك، تم تسجيل أعلى القيم في هذه الصفات من خلال معاملة التداخل بين ١٥٠ جزء في المليون من حمض الساليسيليك و٢٥٠ جزء في المليون من حمض الأسكوربيك في كلا الموسمين، بشكل عام، يمكن أن يستنتج أن ١٥٠ جزءًا في المليون من حمض الساليسيليك + ٢٥٠ جزءًا في المليون من حمض الأسكوربيك، أظهر تأثيرًا موحدًا في التخفيف من تثبيط نمو اللافندر وإنتاجيته في ظل ظروف الملوحة المعتدلة مع زيادة النسبة المئوية لمقاومة الملوحة.

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