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Effect of Salicylic Acid (SA) on Growth and Quality of Stevia (*Stevia rebaudiana* Bert.) Under Salt Stress

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Abstract: Two pot experiments were conducted at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt during consecutive seasons of 2010 and 2011 to evaluate the morphological and chemical behaviors resulting from inducing salinity tolerant in stevia plant induced by salicylic acid foliar application at rates of 0, 50, 75 and 100 mgl^{-1} under irrigation with different saline water (0.4, 2.5, 5.0 and 10.0 dSm^{-1}). The obtained results indicated that increasing irrigation water salinity level from 0.4, 2.5 to 5.0 and/or 10.0 dSm^{-1} induced significantly decrease in all studied growth characters at all cutting in both seasons. On the other hand, saline water irrigation increased stevioside percentage at all cutting in both seasons. Foliar spraying with salicylic acid at 100 mg/l concentration gave the highest significant values for growth characters in two seasons. The effect of the interaction between salinity and salicylic acid was the most effective treatments for growth characters values when stevia plants irrigated by level of salt concentration 2.5 $dSm^{-1}$with foliar salicylic acid at 100 mg/l at all cutting in both seasons.

Key words: Growth characters · Salicylic acid · Salinity · Stevia · Stevioside

INTRODUCTION

Stevia (*Stvia rabaudiana*) is a perennial shrub is belongs to the Asteraceae family, indigenous to the higher elevations. It is a sweet herb gaining significance in different parts of the world. Due to the non-caloric sweeteners extracted from its leaves, mainly stevioside, this paint has gained importance as a crop for the pharmaceutical and food industries. The stevia plant was recently introduced to Egyptian agriculture in order to produce a natural sweetener than can cover some of the lack of sugar production in Egypt [1]. Stevia cultivation in different places of the world; it is expected that in the Egyptian agricultural environment; one faddan (one faddan=0.42ha) of stevia may produce up to 400kg of stevia sugar annually. Taking the sweetening powder of the stevia sugar into consideration; 400 kg of stevia sugar are equivalent to about 80,000 sweetening. Note that one faddan of sugar cane produces about 5,000 sweetening units and one faddan of sugar beet produces about 3,500 sweetening units. A sweetening unit is equivalent to the sweetness of one kilogram of sucrose [1]. Plant species were differed in their sensitivity or tolerance to salt stress [2]. Therefore, the development of salt tolerant plants depends on basis physiological; biochemical may be provided more understanding the term of tolerance. Hence many metabolic changes are known to occur in plants subjected to salt stress [3]. It has been demonstrated in different plant species that treatment with low concentration of salicylic acid (SA) enhances tolerance toward most kinds of a biotic stresses due to an enhanced antioxidant capacity [4]. SA, (2-hydroxy benzoic acid) is an endogenous signal molecular, which may play a role in plant responses to various kinds of stresses [4]. SA, plays an important role in determining the sensitivity of plants [5]. Among a biotic stresses, SA has been reported to counter salinity stress [6, 7]. SA substantially improved growing vigor under salt stress conditions with tomato plants [8]. SA is a phenolic compound naturally occurring in plant in very low amounts and natural signaling molecule, that could be raised to the status of the above phytohormonse because it has significant impact on the various aspects of the plant life [9, 10]. SA was also show to influence number of physiological processes [11]. Several application methods (soaking seeds in SA prior to sowing, adding SA to the

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hydroponics solution, irrigation or spraying with SA solution) have been shown to protect various plant species against a biotic stress factors such as salinity [7, 8] by inducing a wide range of processes involved in stress tolerance mechanisms. SA markedly improved germination under salt stress [12]. However, there are some conflicting reports on the effect of SA on seed germination suggesting that his molecule (*Zea mays*) [13] mainly due to the different treatments studied.

The aim of the present work was to study the effect of salicylic acid on growth and quality of stevia plants under salt stress.

MATERIALS AND METHODS

Pot experiments were carried out in the Experimental Farm of Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt, during the two seasons 2010 and 2011. Seeds of Stevia variety Spain imported from Spain were planted in glass house in Giza Experimental Station, Apicultural Research Center; seedlings aged two months. Stevia seedlings were transplanted on March 30-2010 in plastic pots (25 cm diameter * 50 cm height) filled with 30 kg sand soil Physical and Chemical characteristics of soil was determined according to Chapman and Pratt [14] in 2010 and 2011 seasons (Table 1). The soil in each pot was mixed with farm yard manure (FYM) at a rate of 150g. N-fertilizer was added at a rate of 10g pot^{-1} as ammonium nitrate (33.5%N), after 15 days from sowing and after cutting. All pots received super phosphate (15.5% P_2O_5) at a rate 5 g pot^{-1} in two equal split dressing, before sowing and after 15 days from sowing. Potassium sulfate (48% K_2O) was applied at a 5g pot^{-1} in three equal split dressing after transplanting and after 30 and 60 days from planting. The micronutrients were added a mixed fertilizer (Fe 3%, Zn 3% and Mn 3.5%) at a rate of $1gL^{-1}$ as foliar spraying solution. Four salinity levels of diluted seawater were used in irrigation water. The required quantity of sea water was collected from Gabal Marium, Suez Canal, Ismailia. Potable water available in experimental site was used to dilute seawater in order to get water with different seawater concentrations (0.4, 2.5, 5.0 and 10.0dSm^{-1}). Chemical analysis of diluted seawater used in irrigation water was carried out according to the procedures applied by the US Salinity Laboratory Staff [15] and results are presented in Table 2. Foliar application of salicylic acid was attained the rates of (0, 50, 75 and 100 mg L^{-1}). The plants were sprayed after 30 days from transplanting and after every cut. Four cuttings were taken each two months. The 1st cut at Mid June, 2nd cut at Mid August, 3rd cut at Mid October and the 4th cut at Mid December. At each cut the following data were recorded:

Table 1: Physical and Chemical characteristics of soil for 2010 and 2011seasons

Parameters	Values
Sand%	90.93
Silt%	8.52
Clay%	0.55
Soil texture	Sandy
pH*	7.50
EC**(dSm^{-1})	1.45
OM%	0.67
$CaCO_3$%	0.80
CEC ($molkg^{-1}$)	3.80
Total N%	0.15
Available P ($mgkg^{-1}$)	6.00
Available K ($mgkg^{-1}$)	7.00
Soluble cations** ($meqL^{-1}$)	
Na^+	2.43
K^+	0.74
Ca^{++}	6.50
Mg^{++}	5.50
Soluble anions** ($meqL^{-1}$)	
CO_3^{--}	--
HCO_3^-	6.00
Cl^-	5.50
SO_4^{--}	2.00

*In soil water-suspension 1:2.5

**In soil paste extract

Table 2: Chemical diluted Nile water, Sea water and diluted water used for irrigation.

	Cations ($meqL^{-1}$)				Anions ($meqL^{-1}$)					
Salinity level (ppm)	Ca^{+2}	Mg^{+2}	Na^+	K^+	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}	EC(dSm^{-1})	SAR
Nile water	1.00	1.20	1.8	0.15	-	2.45	1.3	-	0.40	1.30
Sea water	25.50	125.00	350.0	8.50	-	6.50	405.0	125.00	48.50	40.40
1600	2.00	4.00	20.0	0.58	-	2.72	15.2	8.56	2.51	11.50
3200	4.00	8.00	40.0	1.20	-	5.44	30.4	17.00	5.02	16.30
6400	8.00	16.0	80.0	2.30	-	10.90	60.8	34.00	10.04	23.10

- Number of branches/plant.
- Number of leaves/plant.
- Leaf area/plant (cm^2).
- Stem fresh weight/plant (g).
- Leaves fresh weight/plant (g).
- Leaves dry weight/plant (g).
- Stevioside percentage: Stevioside content was determined using High Performance Liquid Chromatography (HPLC) according to Nishiyama *et al.* [16] method as follows: Pure stevioside extraction from leaves was carried out by soaking 1g of dry leaves in 1liter water at 85°C for 30 minutes. Then use Buchner filtration for separation the resulting liquid fraction and wash the residue with an additional volume of hot water (50ml). Lyophyilization was used concentrated the aqueous solution to 50 ml and defatted by ethyl acetate that extracted with isobutyl alcohol (150 ml).The aqueous phase was discarded and the organic solution was evaporated by rotary evaporator at 70°C till drying. The resulting dried extracted was dissolved in hot methanol (100 ml) and kept overnight to crystallize. These crystals were separated by filtration and re-dissolved again in boiling methanol (60 ml). The active charcoal become steady for clarifying the solution and left to recrystallize and finally all previous steps of procedure were repeated till observation of colorless crystals. An isocratic mobile phase with 30% H_2O/methanol (50:50) and 70% acetone was utilized. The flow rate was set at 1 ml/min, the quantity of injected sample was 20 ml, the drift true temperature was 90°C and the flow of repulsing gas was 2.20 stem.

Statistical Analysis: The technique of analysis of variance (ANOVA) and the least significant difference (LSD) was used for means comparison as reported by Gomez and Gomez [17].

RESULTS AND DISCUSSION

Growth Parameters and Quality

Effect of Salinity: Data presented in Tables 3 and 4 indicated that all the studied growth characters and quality i.e. number of branches/plant, number of leaves/plant, leaf area/plant, stems fresh weight/plant, leaves fresh weight/plant, leaves dry weight/ plant and stevioside percentage were significantly affected by irrigation water salinity levels in all cutting dates for two seasons. It is shown that these characters, i.e., number of branches and leaves/plant, leaf area / plant, stems and leaves fresh weight/ plant, as well as, leaves dry weight/plant were increased as salinity levels increased from 0.4 up to 2.5 dSm^{-1} and then decreased at a salinity level treatments 5.0 and 10.0 dSm^{-1}. On the contrary stevioside percentage was increased as salinity levels increased from 0.4 up to 10.0 dSm^{-1} treatment and these results were true in the two growing seasons (Tables 3 and 4). A depression in number of leaves/plant, leaf area/plant and leaves fresh weight/plant was shown as a result of increasing salt concentration up to 10.0 dSm^{-1} in the 1st and 2nd seasons. These results are in agreement with those obtained by Cony and Trione, [2], Ashraf and Waheed [3], Dadkhah and Grrifiths [18], Hussein *et al*. [19], Muhammad *et al*., [20] and Nabila Zaki *et al*. [21]. In this regard, Farkhondeh *et al*. [22] mentioned that, the reduction in growth as a result of salinity may be attributed mainly to the osmotic inhibition of water absorption, the excessive accumulation of ions such as Na^+ or Cl^- in plant cells and inadequate uptake of essential nutrients. In this regard, Marschner [23] stated that, growth reduction due to salinity is mainly attributed to water deficit due to lowered water potential, nutritional imbalance and specific ion toxicity arising from higher concentration of Na^+ and Cl^-. Moreover, Munns [24] added that, highly soluble salts in the root zone cause physiological scarcity in plant to absorb water. Thus, the availability of water may then become so critically low hence growth parameters are inhibited. Recently, Munns and Tester [25] suggested that the depressive effects of NaCl on the growth of plants may be due to ionic toxicity, resulting in inhibition of many physiological and biochemical processes such as nutrient uptake and assimilation.

Effect of Salicylic Acid: Data presented in Tables 3 and 4 show that vegetative growth characters and quality of stevia such as number of branches/plant, number of leaves/plant, leaf area/plant, stem fresh weight/plant, leaves fresh weight/plant, leaves dry weight/plant and stevioside percentage significantly increased at all cutting dates in both seasons as a result to foliar application of salicylic acid, except stem fresh weight/plant at the 3rd cutting in the second season. Salicylic acid at 100 mg/l was the most effective treatment in increasing growth parameters at all cutting in both seasons, while salicylic acid at 75 mg/l was the most effective treatment in increasing leaf area/ plant at the 3rd cutting in the second season. The promotive effect of SA on growth characters could be attributed to its bioregulator effects on

Table 3: Effect of salinity, salicylic acid concentration and their interaction on growth parameters and quality of Stevia at four cuttings in 2010 season.

Characters		Number of branches/plant				Number of leaves/plant				Leaf area/plant (cm^2)			
Treatments		Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
Salinity dSm^{-1}													
0.4		5.83	5.99	6.20	5.95	46.98	54.73	57.57	51.59	285.3	321.5	348.6	308.3
2.5		7.73	7.83	8.26	7.98	57.36	63.04	66.33	59.77	404.3	452.3	482.0	463.0
5.0		7.08	7.17	7.33	7.20	51.94	56.88	52.48	55.15	356.9	387.4	405.3	385.5
10.0		6.80	7.70	8.10	7.81	41.86	45.10	50.55	43.98	217.4	231.4	246.7	237.8
LSD 0.05		0.46	0.38	0.31	0.33	5.45	3.79	1.17	4.31	11.5	11.0	9.5	11.3
Salicylic acid mg/l													
Control		6.20	6.41	6.61	6.53	40.31	43.33	47.70	42.43	248.8	262.2	266.6	255.7
50		6.66	6.90	7.17	7.05	44.51	48.20	51.89	46.4	313.9	337.2	358.6	338.9
75		7.12	7.51	7.91	7.48	52.97	62.13	58.17	58.17	345.8	396.2	420.6	388.0
100		7.45	7.88	8.21	7.88	60.35	66.08	69.73	63.48	355.5	397.0	432.1	412.0
LSD 0.05		0.31	0.28	0.26	0.25	4.51	4.12	3.76	4.41	12.1	10.3	8.9	10.2
Salinity x Salicylic acid													
0.4	Control	4.96	5.11	5.12	5.11	39.91	40.26	45.88	41.52	236.2	244.6	263.5	231.5
	50	5.62	5.72	5.95	5.83	40.52	43.61	47.38	41.67	290.3	301.6	304.8	279.6
	75	6.02	6.32	6.81	6.13	47.21	65.81	67.66	60.33	296.2	399.7	410.8	341.1
	100	6.71	6.81	6.91	6.71	60.27	69.23	69.36	62.82	318.5	340.1	415.2	381.1
2.5	Control	7.06	7.11	7.56	7.41	42.71	47.38	50.33	43.93	319.2	336.1	342.4	339.3
	50	7.53	7.63	7.98	7.91	52.76	56.81	59.66	54.28	397.3	442.3	486.4	461.6
	75	8.11	8.13	8.56	8.13	63.62	73.34	77.10	66.67	449.2	503.2	543.0	511.2
	100	8.21	8.46	8.95	8.46	70.33	74.61	78.22	74.18	451.3	527.6	556.0	539.8
5.0	Control	6.11	6.11	6.21	6.09	40.12	44.33	48.10	43.61	239.5	261.3	265.1	241.6
	50	6.76	6.82	6.99	6.83	45.32	50.13	53.52	48.73	351.7	378.4	395.6	377.8
	75	7.55	7.65	7.81	7.76	59.51	62.76	72.38	61.95	416.3	451.2	476.9	458.9
	100	7.89	8.11	8.31	8.12	62.82	70.28	75.91	66.31	420.2	458.6	483.7	463.7
10.0	Control	6.65	7.31	7.55	7.50	38.51	41.36	46.49	40.66	200.1	206.6	213.4	210.3
	50	6.73	7.42	7.75	7.62	39.45	42.23	46.99	40.92	216.1	226.3	248.0	236.7
	75	6.81	7.93	8.44	7.91	41.53	46.61	50.31	43.71	221.6	230.8	251.7	240.9
	100	6.99	8.13	8.65	8.21	47.96	50.21	55.41	50.62	231.8	261.8	273.5	263.2
LSD 0.05	--	0.48	0.43	0.45	0.42	7.00	6.47	5.90	6.92	18.9	16.1	14.0	16.0

Table 3: Continued

Characters		Stems fresh weight (g/plant)				Leaves fresh weight (g/plant)				Leaves dry weight (g/plant)				Stevioside percentage			
Treatments		Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
Salinity dSm^{-1}																	
0.4		14.45	15.20	16.57	15.15	17.17	17.64	18.11	17.89	5.04	5.29	5.60	5.31	17.85	19.82	20.16	19.66
2.5		17.32	18.34	20.03	17.17	18.09	18.67	19.74	18.74	5.86	6.22	6.56	6.30	19.17	20.81	22.01	21.71
5.0		15.01	15.84	17.37	15.53	17.86	18.37	19.00	18.16	5.27	5.55	6.30	5.87	18.57	20.88	21.88	21.62
10.0		11.55	12.36	13.16	12.20	17.12	17.65	17.80	17.55	5.33	5.87	6.26	5.76	17.94	19.82	20.38	19.63
LSD 0.05		2.11	1.99	1.80	1.91	1.47	0.49	1.17	0.88	0.31	0.63	0.26	0.48	0.44	0.47	0.49	0.48
Salicylic acid mg/l																	
Control		13.57	14.21	15.60	14.36	16.58	16.91	17.40	17.00	5.01	5.48	6.04	5.69	18.06	19.49	20.76	20.06
50		14.43	15.14	16.37	14.67	16.96	17.62	18.15	17.60	5.34	5.70	6.11	5.76	18.16	20.08	20.97	20.40
75		14.80	15.69	17.01	15.21	17.95	18.36	18.99	18.19	5.51	5.79	6.21	5.82	18.43	20.68	21.26	20.81
100		15.54	16.70	18.14	15.80	18.76	19.44	20.10	19.55	5.64	5.95	6.36	5.97	18.88	21.08	21.44	21.34
LSD 0.05		0.48	0.93	1.02	0.23	0.39	0.75	0.91	1.08	0.11	0.15	0.12	0.14	0.27	0.29	0.15	0.33
Salinity x Salicylic acid																	
0.4	Control	13.27	14.33	15.25	14.81	16.25	16.79	17.22	16.92	4.62	4.95	5.36	5.17	17.67	19.23	19.56	19.41
	50	14.53	15.16	16.63	14.96	16.94	17.56	17.89	17.30	5.06	5.21	5.48	5.25	17.68	19.56	19.76	19.55
	75	14.67	15.21	16.74	15.00	17.53	17.91	18.63	18.01	5.16	5.27	5.62	5.38	17.74	19.96	20.46	19.65
	100	15.31	16.10	17.66	15.81	17.94	18.30	18.69	19.33	5.31	5.73	5.92	5.44	18.30	20.53	20.84	20.01
2.5	Control	16.62	16.91	19.10	16.67	17.21	17.36	18.11	17.63	5.68	6.08	6.47	6.16	19.00	19.76	21.67	21.35
	50	16.71	17.51	19.33	16.91	17.23	17.81	18.37	17.97	5.73	6.16	6.48	6.27	19.03	20.84	21.91	21.56
	75	17.35	18.31	19.66	17.42	18.36	18.91	19.94	18.41	5.96	6.30	6.58	6.31	19.23	21.28	22.13	21.93
	100	18.61	20.61	22.02	17.66	19.56	20.61	22.53	20.95	6.08	6.32	6.71	6.47	19.41	21.34	22.33	21.98
5.0	Control	14.21	14.37	16.33	14.88	16.54	19.93	17.39	17.12	4.68	5.17	6.17	5.81	18.13	19.61	21.56	20.81
	50	15.16	16.24	17.13	15.11	17.13	17.59	18.66	17.80	5.23	5.58	6.27	5.85	18.14	20.31	21.91	20.93
	75	15.28	16.32	17.82	15.82	18.27	18.51	19.10	18.16	5.48	5.66	6.35	5.89	18.65	21.66	22.13	20.81
	100	15.39	16.43	18.20	16.31	19.51	20.43	20.83	19.56	5.68	5.77	6.41	5.91	19.34	21.93	21.97	22.91
10.0	Control	10.16	11.23	11.73	11.06	16.32	16.55	16.88	16.34	5.06	5.73	6.16	5.63	17.43	19.34	20.25	18.67
	50	11.31	11.63	12.38	11.71	16.52	17.52	17.68	17.34	5.34	5.85	6.19	5.67	17.79	19.61	20.31	19.56
	75	11.91	12.91	13.84	12.61	17.62	18.12	18.27	18.16	5.45	5.91	6.27	5.68	18.08	19.81	20.33	19.83
	100	12.83	13.67	14.67	13.41	18.02	18.41	18.36	18.35	5.48	5.97	6.41	6.05	18.45	20.53	20.62	20.46
LSD 0.05	--	0.75	1.46	1.60	0.36	0.61	1.17	1.43	1.70	0.17	0.24	0.19	0.22	0.42	0.46	0.24	0.52

Table 4: Effect of salinity, salicylic acid concentration and their interaction on growth parameters and quality of Stevia at four cuts in 2011 season .

Characters		Number of branches/plant				Number of leaves/plant				Leaf area /plant (cm^2)			
Treatments		Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
Salinity dSm^{-1}													
0.4		7.86	8.06	8.46	7.28	44.59	46.73	51.44	46.35	302.8	312.6	334.6	309.2
2.5		8.52	8.93	8.99	8.20	59.29	64.06	68.11	64.87	335.0	344.2	362.4	339.1
5.0		8.32	8.65	8.79	7.74	52.89	55.92	61.60	57.44	313.0	319.7	337.5	315.9
10.0		7.74	7.86	8.08	7.70	48.31	49.29	53.11	52.30	292.4	299.4	309.4	297.6
LSD 0.05		0.29	0.57	0.25	0.39	1.51	1.26	0.91	0.92	6.9	8.4	9.9	7.7
Salicylic acid mg/l													
Control		7.66	7.91	8.16	7.23	43.26	46.65	49.69	48.21	297.0	302.3	316.3	300.4
50		7.99	8.19	8.37	7.71	45.82	47.69	52.88	50.27	308.3	315.5	334.9	311.8
75		8.25	8.53	8.73	7.86	55.40	59.76	64.92	59.74	316.6	326.1	343.9	321.1
100		8.54	8.85	9.06	8.13	60.59	61.90	66.76	62.75	323.9	331.9	321.1	328.5
LSD 0.05		0.35	0.32	0.40	0.31	5.11	5.02	4.46	4.47	6.7	5.36	7.5	6.6
Salinity x Salicylic acid													
0.4	Control	7.26	7.65	8.00	6.78	40.47	42.81	46.15	43.91	280.6	291.9	326.8	289.8
	50	7.69	7.83	8.35	7.21	41.69	43.96	49.43	45.98	302.5	311.5	334.5	308.2
	75	8.13	8.17	8.56	7.56	45.98	48.95	53.26	47.12	311.5	319.5	337.9	317.1
	100	8.36	8.54	8.93	7.56	50.21	51.19	56.91	48.38	316.7	327.4	339.1	321.8
2.5	Control	8.20	8.45	8.61	7.73	45.98	50.60	52.35	53.26	319.7	320.5	325.0	316.8
	50	8.33	8.73	8.76	8.15	49.61	51.19	58.21	56.91	331.0	334.9	356.1	333.2
	75	8.62	9.09	9.14	8.29	66.18	75.86	79.90	69.81	341.8	359.7	380.9	349.1
	100	8.93	9.43	9.43	8.61	75.37	78.57	81.98	79.48	347.6	361.5	387.4	357.1
5.0	Control	8.00	8.12	8.34	6.88	44.81	49.08	51.32	50.61	300.2	305.2	310.8	304.7
	50	8.21	8.43	8.52	7.74	46.58	49.16	54.03	51.53	306.7	319.1	341.5	310.2
	75	8.35	8.93	9.11	7.83	58.25	61.34	70.24	63.51	315.7	322.8	346.1	318.3
	100	8.71	9.11	9.18	8.52	61.91	64.12	70.81	64.12	329.3	331.6	351.7	330.3
10.0	Control	7.18	7.43	7.68	7.51	41.78	44.11	48.95	45.05	287.4	291.7	302.7	290.3
	50	7.73	7.78	7.85	7.72	45.39	46.46	49.86	46.66	293.0	296.3	307.5	295.6
	75	7.90	7.93	8.09	7.76	51.20	52.90	56.29	58.50	297.2	302.4	310.8	299.7
	100	8.16	8.31	8.70	7.81	54.85	53.70	57.35	59.00	301.8	307.1	316.5	304.8
LSD 0.05	--	0.55	0.50	0.63	0.49	8.02	7.90	7.00	7.02	10.5	8.4	11.8	10.4

Table 4: Continued

Characters		Stems fresh weight (g/plant)				Leaves fresh weight (g/plant)				Leaves dry weight (g/plant)				Stevioside percentage			
Treatments		Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
Salinity dSm^{-1}																	
0.4		17.29	17.59	18.07	17.60	18.33	18.65	19.06	18.46	4.99	5.19	5.89	5.06	18.39	19.02	19.84	20.51
2.5		18.16	18.43	18.83	18.27	19.86	20.23	20.73	20.04	5.65	6.03	6.61	5.85	20.86	21.87	22.38	22.99
5.0		17.79	18.14	18.47	17.97	19.07	19.96	20.31	19.34	5.25	5.92	6.44	5.63	19.80	20.35	21.25	22.27
10.0		17.24	17.80	18.17	17.69	17.44	22.13	18.07	17.54	4.51	4.65	4.90	4.57	21.73	22.13	22.55	23.13
LSD at 5%		0.58	0.45	0.38	0.56	0.71	0.76	0.72	0.66	0.61	0.58	0.47	0.49	0.49	0.48	0.51	0.54
Salicylic acid mg/l																	
Control		14.75	17.58	18.14	17.47	18.05	18.59	18.97	18.28	4.85	5.28	5.77	5.05	19.23	19.81	20.38	21.04
50		17.50	17.80	18.24	17.82	18.50	18.89	19.37	18.69	5.06	5.36	5.88	5.29	19.95	20.71	21.26	22.04
75		17.66	18.13	18.47	18.03	18.92	19.29	19.69	19.05	5.19	5.51	6.00	5.36	20.51	21.20	21.85	22.63
100		17.91	18.45	18.46	18.21	19.23	19.74	20.14	19.37	5.30	5.65	6.19	5.43	21.10	21.63	22.54	23.19
LSD at 5%		0.24	0.28	n.s	0.14	0.47	0.40	0.49	0.22	0.10	0.14	0.15	0.16	0.46	0.38	0.61	0.57
Salinity x Salicylic acid																	
0.4	Control	16.95	17.13	17.91	17.28	17.26	18.03	18.31	17.83	4.89	5.05	5.67	4.96	18.11	18.67	19.34	19.80
	50	17.16	17.40	17.98	17.60	18.18	18.36	18.93	18.31	4.93	5.08	5.76	5.04	18.27	18.83	19.57	20.51
	75	17.34	17.76	18.11	17.70	18.57	18.71	19.25	18.63	5.00	5.26	5.93	5.12	18.48	19.17	19.81	20.61
	100	17.70	18.08	18.25	17.80	19.31	19.51	19.74	19.07	5.13	5.38	6.20	5.13	18.71	19.39	20.65	21.11
2.5	Control	17.93	18.17	18.53	17.93	19.31	19.87	20.14	19.13	5.06	5.86	6.42	5.72	19.57	20.78	21.16	21.56
	50	18.13	18.28	18.75	18.13	19.63	19.98	20.48	20.05	5.68	5.96	6.60	5.85	20.61	21.65	22.08	22.47
	75	18.17	18.47	18.87	18.37	20.13	20.34	20.79	20.35	5.87	6.06	6.63	5.86	21.36	22.31	22.95	23.73
	100	18.41	18.78	19.18	18.64	20.36	20.72	21.51	20.64	5.98	6.25	6.79	5.98	21.89	22.74	23.34	24.21
5.0	Control	17.36	17.63	18.17	17.58	18.61	19.21	19.81	18.98	5.05	5.69	6.32	5.07	18.91	19.46	20.31	21.46
	50	17.59	17.91	18.24	17.83	18.96	19.73	20.12	19.11	5.13	5.73	6.34	5.69	19.51	20.21	20.76	22.06
	75	17.98	18.24	18.56	18.07	19.34	20.31	20.63	19.53	5.32	6.03	6.46	5.83	20.16	20.65	21.48	22.61
	100	18.24	18.77	18.89	18.38	19.36	20.57	20.69	19.73	5.49	6.21	6.65	5.94	20.63	21.06	22.46	22.95
10.0	Control	16.76	17.38	17.93	17.09	17.01	17.25	17.61	17.18	4.39	4.53	4.68	4.44	20.31	20.35	20.73	21.34
	50	17.12	17.61	17.98	17.70	17.21	17.48	17.93	17.27	4.49	4.65	4.81	4.58	21.41	22.15	22.62	23.11
	75	17.15	18.04	18.29	17.96	17.63	17.81	18.10	17.69	4.56	4.68	4.98	4.62	22.03	22.68	23.15	23.57
	100	17.91	18.16	18.46	18.01	17.89	18.17	18.63	18.03	4.59	4.74	5.13	4.65	23.17	23.32	23.70	24.48
LSD 0.05	--	0.38	0.44	0.33	0.22	0.74	0.63	0.77	0.35	0.16	0.22	0.24	0.25	0.72	0.60	0.96	0.89

physiological and biochemical processes in plants such as ion uptake, cell elongation, cell division, cell differentiation, sink and source regulation, enzematic activities, protein synthesis and photosynthetic activity; as well as; increase the antioxidant capacity of plant [7, 11, 26]. Salicylic acid as antistress substance may enhance the plant tolerance to environmental stresses [27]. Similar results were obtained by Borsani *et al*. [5], Khan *et al*. [28] on corn and soybean, Shakirova *et al*.[29] on wheat, Khodary [6] on maize, El-Khallal *et al*. [30], Delavar *et al*. [31]. Gharib and Hegazi [10] and Shalaby *et al*. [32] on different plant species. Also, El–Mergwi and Abd El-Wahed [33] found that the types of plants varied in their response to salicylic acid application as a result to genotype variation. Also, Abd El–Whed *et al*. [34] found that increasing vegetative character values were obtained at salicylic acid (3mM) of yellow maize plants.

Effect of Interaction Between Salinity and Salicylic Acid: Data in Tables 3 and 4 shows that the interaction between salinity and salicylic acid caused significant effects on number of branches/ plant, number of leaves/plant, leaf area/plant, stem fresh weight/plant, leaves fresh weight plant, leaves dry weight/plant and stevioside percentage in all cutting dates for two seasons. Data also indicated that the most effective treatments for growth characters values was obtained when stevia plants irrigated by level of salt concentration 2.5 dS/m with foliar salicylic acid at 100 mg/l, at all cutting in both seasons, meanwhile, treatment irrigated by high level of salt concentration 10.0 dS/m with foliar salicylic acid at 100 mg/l had the highest stevioside percentage at all cutting dates in the second season. Also, treatment irrigated by level of salt concentration 2.5 dS/m with foliar salicylic acid at 100 mg/l, as well as, 5.0 dS/m with foliar salicylic acid at 100 mg/l had the highest stevioside percentage at the 1st, 3rd, 2nd and 4th cuttings in the first season, respectively.

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