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RESPONSE OF SALTBUSH (*ATRIPLEX HALIMUS* L.) PLANTS TO SALINITY AND TYPE OF GROWING MEDIUM

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ABSTRACT: A pot experiment was carried out under the full sun at Orman Botanic Garden, Hort. Res. Inst., Giza, Egypt during 2013 and 2014 seasons in order to reveal the effect of different media, namely: pure sand, pure loam and sand + loam mixture at 1:1, 1:2 and 2:1 ratio salinized with a homogenous salt mixture of NaCl and $CaCl_2$ (1:1, w/w) at 0.00, 0.75, 1.5 and 3.0% concentrations on growth and chemical composition of the 6-months-old transplants of Mediterranean saltbush (*Atriplex halimus* L.) cultivated in 40-cm-diameter clay pots filled with a known weight of the abovenamed media.

The results of this experiment have shown that all vegetative and root growth measurements were significantly improved by the law and medium levels of salinity (0.75 and 1.5%, respectively), with the mastery of 0.75% level which gave the highest means various growth traits except of leaf area character that reached the maximum values by 1.5% level over control and other salinity treatments in the two seasons. However, 3.0% rate significantly reduced means of the different vegetative and root growth parameters to the least values compared to control in most cases of both seasons. The mixture of sand + loam, especially at 1:2 and 2:1 ratio recorded the best improvement in vegetative and root growth parameters over all other media in the two seasons. The interaction between the 3 used mixtures salinized with 0.75% of salt mixture gave the tallest plants, thickest stems and highest No. branches and leaves/plant in both seasons, while the heaviest fresh and dry weights of aerial parts and roots were achieved by 0.75% salinity level for plants cultivated in either pure sand or pure loam, or in the mixture of both at equal parts (1:1). The content of chlorophyll a, b and carotenoids was slightly improved by either soil salinity treatments or media contained loam granulars. On the other side, the content of Na, Ca, Cl and free proline was progressively increased with raising salinity level, but the opposite was the right concerning K content, which descendingly decreased with increasing salinity rate. The content of Na and Cl was not markedly affect by medium type, whereas content of K, Ca and free proline was greatly increased in the leaves of plants cultivated in pure loam or pure sand amended with loam at any ratio. The interaction treatments have shown variable effects, as the highest content of Na and K was mostly achieved by the low (0.75%) and medium (1.5%) salinity treatments under loam or sand or sand + loam media, while the highest content of Ca, Cl and proline was scored by plants cultured in loam or sand + loam media salinized with the high salinity rate (3.0%).

It appears from the previous results that Mediterranean saltbush (*Atriplex halimus* L.) plants can grow well in the loam or sand amended with loam media salinized with NaCl + $CaCl_2$ salt mixture (1:1, w/w) at low and medium concentrations.

Key words: Mediterranean saltbush, *Atriplex halimus* L., soil salinization, type of media, salinity tolerance, vegetative and root growth, chemical composition.

INTRODUCTION

Atriplex halimus L., Mediterranean saltbush, sea purslane or sea orache (Fam. Chenopodiaceae) is a perennial shrub, up to 2 m height or less and 3 m wide, native to Mediterranean basin with an excellent tolerance to drought and salinity (Bailey, 1976). It can easily grown from seeds (sow in the spring and germinate in about 3 weeks) and also from cuttings which can be taken from semi-ripe wood in the summer or mature wood in the winter. It can grow in alkaline or salty soil. Its leaves are a pale green grey (or silver) in colour and have a lovely salty taste when used in salads. They can also be dried and ground down to use as a flavoring. The small seeds are cooked before eating (Huxley *et al*., 1992). It is characterized by its rapid growth, high biomass production and deep root system, so able to cope with poor structure and xeric characteristics of polluted soils. It is a promising alternative for the removal of heavy metals, including Pb and Cd and for soil desalination (Manousaki and Kalogerakis, 2009). In this respect, deSauzaa *et al*. (2014) recommended to use of the Atriplex for revegetating areas in hospitable to most species used in conventional farming.

For optimal growth *Atriplex halimus* requires slight salinization of the growth substrate. It tolerates higher salt concentrations, but those above 14 atm retard growth (Blumenthal-Goldschmidt and Poljakoff-Mayber, 1968). In contrast to most plants, Na^+ absorption by *A. halimus* was not inhibited by high concentrations of K^+ in the culture medium, while K^+ absorption was greatly reduced by excess Na^+ in the growing medium. In Na^+ and K^+ were present at equal concentrations, Na^+ uptake was twice as great as K^+. a specific site for Na^+ absorption which is not inhibited by excess K^+ in *A. halimus* was postulated (Mozafar *et al*., 1970). Moreover, Matoh *et al*. (1986) found that plants of *Atriplex gmeline* received nutrients supplemented with 50 mM NaCl gave the maximum dry weight compared to those received the higher or the lower concentrations of NaCl. Addition of 50 mM KCl, 25 mM Na_2SO_4 or 25 mM K_2SO_4 to the base culture also stimulated the growth to the same extent, while higher concentrations of K+ salts, such as 250 mM KCl or 125 mM K_2SO_4 exerted a more deleterious effect on the plant growth than Na + salts did. At a concentration of 250 mM NaCl or KCl addition, the KCl-treated plants showed a higher Na^+ + K^+ concentration than the NaCl-treated plants. The plants exposed to 250 mM NaCl were able to maintain their internal Na^+ + K^+ concentrations around certain values, while the internal Na^+ + K^+ concentration in the 250 mM KCl-treated plants increased linearly.

Sadder (2013) mentioned that *A. halimus* is a xero-*halophte* shrub adapted to extreme drought and salinity stresses. These characteristics are controlled by special genes which their expression was much higher at 150 mM than 300 mM NaCl stress level, indicating their specificity for low level salt stress. Photosynthetic activity was slightly decreased with both extended stress exposure and increased salt concentration, while total chlorophyll and proline increased under saline stress. Similar observations were also recorded on other trees and suburbs, such as those of Al-Qubaie *et al*. (2003) on *Ficus benghalensis, Tamarix articulata, Jasminum azoricum, Concarpus erectus* and *Ziziphus spina-christi*, Mahmoud

(2005) on *Cocos romanzoffiana*, *Livistona chinensis*, *Sabal palmetto* and *Washingtonia filifera.* Shahin *et al*. (2008) on *Ficus macrocarpa* var. Hawaii and *Euonymus japonica*, Abdel-Fattah *et al*. (2012) on *Ficus retosa* and Shahin *et al*. (2013) on *F. benjamina* cv. Smantha and *Schefflera arboricola* cv. Gold Capella.

This work was set out in order to study the effect of salinized different media on growth performance and chemical composition of saltbush plants.

MATERIALS AND METHODS

This investigation was performed under the full sun at Orman Botanic Garden, Hort. Res. Inst., Giza, Egypt during the two successive seasons of 2013 and 2014 to explore the response of saltbush plants grown in different media salinized with the various levels of NaCl + $CaCl_2$ salt mixture.

Thus, six months-old, uniform transplants of saltbush (*Atriplex halimus* L.) at a length of about 25 cm were planted on April, 1st for each season in 40-cm-diameter clay pots (one transplant/pot) filled with one type of the following media: pure sand, pure loam, as well as sand + loam mixture at the following ratios 1:1, 1:2 and 2:1. The physical and chemical properties of the sand and loam used in the two seasons are shown in Table (1).

The pots were filled with each one of the above-named media 1 inch before the rim. Then, weight of each medium occupied that space was calculated individually. Thereafter, the used media were salinized with an equal mixture of Nacl and $CaCl_2$ pure salts (1:1, by weight) at the following concentrations: 0.00, 0.75, 1.5 and 3.0 %. Hereafter, Table (2), showing the amount of salt mixture which was added to each pot according to type of medium and its weight.

The treatments of media and salinization were combined factorially to create 20 interaction treatments. Immediately after planting the transplants were irrigated with 400 ml of fresh water/pot, twice a week till the end of experiment on October, 1st.

Table 1. The physical and chemical properties of the sand and loam used in the two seasons.

Soil texture	Seasons	Particle size distribution (%)				S.P.	E.C. (dS/m)	pH	Cations (meq/l)				Anions (meq/l)		
		Coarse sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}
Sand	2013	89.03	2.05	0.40	8.52	23.01	3.56	7.90	7.50	1.63	33.60	0.50	3.20	22.00	18.03
	2014	84.76	6.29	1.50	7.45	21.87	3.71	7.80	19.42	8.33	7.20	0.75	1.60	7.80	26.30
Loam	2013	10.18	46.17	19.53	24.12	35.00	3.48	8.27	17.50	9.42	20.00	0.79	3.80	10.00	33.91
	2014	10.30	46.54	18.88	24.28	33.07	3.36	7.96	18.00	8.95	20.50	0.85	3.65	10.20	34.45

Table 2. The salts mixture weight (g) added to each pot according to medium type and its weight filling it 1 inch before the rim in both seasons.

Medium / Soil salinity	Sand		Loam		Sand + loam (1:1)		Sand + loam (1:2)		Sand + loam (2:1)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Medium weight (kg/pot)	9.73	9.81	7.47	7.53	8.00	8.10	8.80	8.71	9.00	8.92
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75 % salinity	73.00	73.58	56.00	56.48	60.00	60.75	66.00	65.33	67.50	66.90
1.50 % salinity	146.00	147.16	112.00	112.96	120.00	121.50	132.00	130.66	135.00	133.80
3.00 % salinity	219.00	220.74	168.00	169.44	180.00	182.25	198.00	195.99	202.50	200.70

However, the other agricultural practices required for such plantation were done well whenever needed. The pots were arranged in the two seasons in a factorial complete randomized design replicated thrice with 5 transplants per replicate (Mead *et al*., 1993). At the end of each season, data were recorded as follows plant height (cm), stem diameter at the base (cm) number of branches and leaves/plant, leaf area (cm^2) as well as fresh and dry weights of aerial parts and roots (g).

In fresh leaf samples taken from the middle parts of plants, the photosynthetic pigments content (chlorophyll a, b and carotenoids, mg/g f.w.) was determined according to the method described by Saric *et al*. (1967), while in dry leaf samples, the percentages of sodium and potassium as well as chloride in mg/g d.w. (Jackson, 1973) and calcium (Dewis and Freitas, 1970) were measured. Furthermore, content of the free amino acid proline as µmoles/g d.w. was assessed using the method explained by Bates *et al*. (1973).

Data were then tabulated and the morphological ones were undergone to analysis of variance using the program of SAS Institute Program (1994), followed Duncan's Multiple Range Test (Duncan, 1955), to detect the significancy among the means of various treatments.

RESULTS AND DISCUSSION

Effect of salinity, media and their interactions on:

1- Vegetative and root growth parameters:

It is obvious from data illustrated in Tables (3, 4, 5, 6 and 7) that all vegetative and root growth parameters, expressed as plant height (cm), stem diameter (cm), number of branches and leaves/plant, leaf area (cm^2), as well as fresh and dry weights of aerial parts and roots (g) were significantly improved as a result of planting in media salinized with the medium levels of salt mixture (0.75 and 1.5%) with the superiority of 0.75% level that gave the highest means of all above-named traits except of leaf area criterion which reached the maximum by 1.5% level over control and other salinity treatments in the two seasons. On the other hand, 3.0% salinity level significantly reduced all vegetative and root growth characters compared to control in most cases of the two seasons.

These results may demonstrated that growth of saltbush plants was strongly stimulated by low level of saline media containing equal parts of NaCl and KCl or $CaCl_2$, as indicated before by Mozafar *et al*. (1970) and Blumenthal-Goldschmidt and Poljakoff-Mayber (1968). In this regard, Manousaki and Kalogerakis (2009) noticed that salt toxicity symptoms were observed only in *A. halimus* plants treated with 3% NaCl solution. The reduction of growth due to high salinity may be attributed to a decrease in all volume at a constant cell number caused by salinity (deSouzaa, 2014). Sadder (2013) mentioned that mechanism of salt may result in cell division inhibition and hence reduces the rate of plant growth. Moreover, Gale and Poljakoff-Mayber (1970) stated that there are at least 3 different effects of salinity on *A. halimus* plants: an increase of leaf area and succulence induced by relatively low concentration of salt in the growth medium, an increase of stomatal resistance to water vapour loss, this tended to reduce transpiration per unit of leaf area and changes in mesophyll resistance to CO_2 uptake which reduced by relatively low concentration of NaCl. In addition, salinity may have caused a hormonal imbalance which increased sprouting of lateral buds.

Blumenthal-Goldschmidt and Poljakoff-Mayber (1968) affirmed that some changes occur in the submicroscopic structure of leaf cells of *A. halimus* at 9-14 atm salt concentration, including : swelling of chloroplasts and mitochondria, appearance of numerous large lipid droplets, swelling of the nuclear membranes, extensive vacuolization and distortion of the transplant with formation of numerous myelin bodies. Besides, Smaoui *et al*. (2011) revealed that *A. halimus* has secreting glandular trichomes which are recognized as an efficient structure

Table 3. Effect of soil salinity, medium and their interactions on plant height and stem diameter of *Atriplex halimus* L. plants during 2013 and 2014 seasons.

Salinity treatments / Medium	Plant height (cm)						Stem diameter (cm)					
	Sand (S)	Loam (L)	S + L (1 : 1)	S + L (1 : 2)	S + L (2 : 1)	Mean	Sand (S)	Loam (L)	S + L (1 : 1)	S + L (1 : 2)	S + L (2 : 1)	Mean
First season: 2013												
Control	122.00f	140.33e	168.00c	165.37cd	176.58bc	154.46b	0.50f	0.68e	0.99d	1.23c	1.36bc	0.95b
0.75% salinity	150.33d	165.00cd	173.11bc	185.43b	199.17a	174.61a	0.60e	0.80de	1.21c	1.50b	1.78a	1.18a
1.50% salinity	145.10de	149.63d	170.46c	181.90bc	184.25b	166.27ab	0.63e	0.75de	1.10cd	1.42b	1.54ab	1.09a
3.00% salinity	154.78i	69.50h	99.00g	121.00f	120.64f	92.99c	0.50f	0.61e	0.88d	0.96d	1.00cd	0.79c
Mean	118.05d	131.12e	152.64b	163.43ab	170.16a		0.56d	0.71c	1.05b	1.28ab	1.42a	
Second season: 2014												
Control	113.50d	130.48cd	148.36b	149.00b	152.26b	138.72b	0.50e	0.63d	0.92c	1.06b	1.10b	0.84b
0.75% salinity	137.81c	153.43b	160.89ab	163.05ab	169.15a	156.87a	0.63d	0.75cd	1.13b	1.40a	1.39a	1.06a
1.50% salinity	134.69c	137.60c	156.78b	159.65ab	153.29b	148.40ab	0.67cd	0.70cd	1.02bc	1.28ab	1.43a	1.02a
3.00% salinity	61.35g	77.85f	101.89e	112.37d	112.16d	93.13c	0.46e	0.60d	0.81c	0.85c	0.86c	0.72b
Mean	111.84c	124.84b	141.98a	146.02a	146.72a		0.57c	0.67c	0.97b	1.15a	1.20a	

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table 4. Effect of soil salinity, medium and their interactions on number of branches and number of leaves of *Atriplex halimus* L. plants during 2013 and 2014 seasons.

Salinity treatments \ Medium	No. branches/plant						No. leaves/plant					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
							First season: 2013					
Control	9.00e	10.33d	12.40c	14.00b	13.03bc	11.75bc	795.00i	823.50h	990.08f	1017.87ef	1048.33e	934.96c
0.75% salinity	12.41c	13.76bc	15.31ab	17.50a	16.51a	15.10a	1001.33f	1036.00e	1279.00b	1326.91a	1331.98a	1195.05a
1.50% salinity	10.33d	11.00cd	12.83c	15.00cd	13.62bc	12.56b	916.42g	988.17f	1121.36d	1213.02c	1208.27c	1089.45b
3.00% salinity	6.76f	8.50e	10.76d	11.98cd	14.75b	10.55c	613.10k	638.45k	748.08j	834.70h	897.54g	746.37d
Mean	9.63c	10.90b	12.83ab	12.12ab	14.48a		831.46d	871.53e	1034.63b	1098.13ab	1121.53a	
							Second season: 2014					
Control	8.33d	9.58cd	10.78c	11.18b	10.56c	10.09b	739.35e	762.40d	856.31cd	871.60cd	864.90cd	818.91c
0.75% salinity	10.56c	11.74b	12.96a	13.97a	12.81a	12.41a	930.00bc	961.55b	1037.88a	1066.58a	1031.87a	1005.58a
1.50% salinity	11.32b	11.03bc	12.08ab	12.64ab	11.48b	11.71ab	854.88cd	914.00c	965.23b	991.67ab	967.36b	938.63b
3.00% salinity	7.09e	8.89d	9.63cd	10.33c	10.17cd	9.22c	576.61g	595.21g	697.50ef	707.33e	691.92f	653.72d
Mean	9.33c	10.31b	11.36ab	12.03a	11.26ab		775.21d	808.29c	889.23b	909.30a	889.13b	

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table 5. Effect of soil salinity, medium and their interactions on leaf area (cm^2) of *Atriplex halimus* L. plants during 2013 and 2014 seasons.

Medium / Salinity treatments	First season: 2013						Second season: 2014					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
Control	5.58g	8.52e	6.75f	7.96ef	9.33d	7.63c	6.29fg	9.85d	7.40ef	6.38f	8.27e	7.76c
0.75% salinity	8.81e	11.01c	9.48d	11.80c	12.18bc	10.66b	9.74d	12.15bc	10.65cd	12.43bc	11.70c	11.33b
1.50% salinity	8.57e	12.79b	12.92b	16.83a	14.46ab	13.12a	9.65d	11.71c	14.42b	17.35a	12.63bc	13.15a
3.00% salinity	5.19g	7.94ef	6.29fg	7.03f	8.63e	7.02c	5.46g	8.60de	6.39f	5.91g	7.23ef	6.77d
Mean	7.04c	10.07ab	8.86b	10.91a	11.15a		7.79c	10.58a	9.72b	10.52a	9.96ab	

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table 6. Effect of soil salinity, medium and their interactions on fresh and dry weights of aerial parts of *Atriplex halimus* L. plants during 2013 and 2014 seasons.

Medium / Salinity treatments	Aerial parts fresh weight (g)						Aerial parts dry weight (g)					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
First season: 2013												
Control	220.21e	253.76d	287.11c	265.21cd	205.00ef	246.26c	149.46c	154.89c	106.59e	97.48ef	93.18ef	119.72c
0.75% salinity	300.53bc	369.83ab	382.75a	358.34ab	310.89b	344.47a	208.65ab	218.67a	208.61ab	174.50b	151.93c	192.47a
1.50% salinity	274.50c	316.28b	319.87b	320.31b	239.67de	294.13b	181.26b	169.70bc	126.90d	128.71d	117.15de	144.75b
3.00% salinity	105.71h	121.44g	139.76fg	156.35f	120.95g	128.84d	70.32f	74.40f	51.38g	57.53g	55.00g	61.73d
Mean	225.24c	265.33b	282.37a	275.05ab	219.13c		151.67a	154.42a	123.37b	114.56bc	104.32c	
Second season: 2014												
Control	203.80e	233.30d	266.23c	230.20d	210.37e	228.77c	117.43cd	134.20c	99.51d	92.00d	89.49de	106.53c
0.75% salinity	268.10c	319.15ab	330.41a	309.64ab	268.12c	299.08a	179.90a	186.55a	160.87ab	150.46b	130.60c	161.68a
1.50% salinity	249.74cd	291.81b	296.67b	278.77bc	223.29d	268.06b	154.47b	146.18bc	117.20cd	117.00cd	108.71d	128.71b
3.00% salinity	113.40g	130.68fg	125.0fg	144.92f	112.43g	125.39d	75.92e	79.93e	55.51f	60.20f	59.40f	66.19d
Mean	208.76c	243.74b	254.70a	240.88b	203.54c		131.93a	136.72a	108.27b	104.92b	97.05c	

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table 7. Effect of soil salinity, medium and their interactions on fresh and dry weights of roots of *Atriplex halimus* L. plants during 2013 and 2014 seasons.

Salinity treatments \ Medium	Roots fresh weight (g)						Roots dry weight (g)					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
First season: 2013												
Control	120.00d	138.93c	162.37b	143.51c	99.46e	132.85b	61.02d	66.50cd	70.10c	65.21cd	43.89e	61.34c
0.75% salinity	175.33ab	180.46ab	190.11a	163.70b	130.78cd	168.08a	92.25b	101.03ab	117.89a	91.00b	74.76c	95.39a
1.50% salinity	142.67c	165.73b	179.82ab	152.84bc	121.13d	152.44ab	70.21c	75.39c	89.98b	70.34c	50.21de	71.23b
3.00% salinity	57.63fg	68.72f	85.24ef	83.10ef	51.70g	69.28c	29.90f	32.58ef	34.36ef	37.89ef	26.58f	32.26d
Mean	123.91c	138.46b	154.39a	135.79b	100.77d		63.35b	68.88b	78.08a	66.11b	48.86c	
Second season: 2014												
Control	110.61cd	120.56c	137.11b	131.98bc	91.07d	118.27b	53.71d	59.38cd	60.43cd	58.45cd	50.16d	56.43c
0.75% salinity	151.36ab	163.40a	164.33a	149.60ab	120.90c	149.92a	79.67b	86.69ab	97.11a	78.71b	69.75c	82.39a
1.50% salinity	130.10bc	147.71b	152.82ab	140.35b	112.43c	136.68ab	63.10c	67.75c	80.76b	64.10c	60.33cd	67.21b
3.00% salinity	62.21e	74.20de	79.16de	76.19de	53.69e	69.09c	30.78e	33.28e	35.70e	35.33e	30.36e	33.09d
Mean	113.57b	127.47ab	133.36a	124.53ab	94.52e		56.82b	61.78ab	68.50a	59.15b	52.65c	

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

that alleviates salt effects on such plant. They are found on buds, young green stems and occupy both the leaf surfaces and give them a whitish colour. In this concern Mozafar and Goodin (1970) found that the concentration of salt in the vesiculated hairs of *A. halimus* was remarkably higher than that of the leaf sap and xylem exudate. This observation indicates that in *A. halimus* the vesiculated hairs play a significant role in removing salts from the remainder of the leaf and preventing the accumulation of toxic salts in the parenchyma and vescular tissues. Thus, a nearly constant salt content is maintained in leaf cells other than the hairs.

As for the effect of media, data indicated that sand + loam mixtures registered the best results compared to the pure sand or loam in most cases of the two seasons, with the prevalence of 1 :2 and 2:1 (S + L) ratio which often recorded the highest averages in both seasons. This may be due to that saltbush plants grow well in any light, well-drained, but not too febrile soil (Rofe, 2012). Cultivating in either pure sand or pure loam scored only the heaviest aerial parts dry weights over the 3 used soil mixtures in the two seasons, whereas cultivating in the equal mixture of sand + loam (1:1) gave the heaviest fresh and dry weights of roots relative to the other media used in both seasons.

The interaction treatments were also exhibited a marked effect on growth of saltbush plants where planting in the 3 mixtures salinized with 0.75% of salt mixture gave the best plant height, stem diameter and No. of branches and leaves/plant in the two seasons, while the best leaf are was attained by the interaction between sand + loam mixture (1:2) and salinization with 1.5% of salt mixture. However, the heaviest fresh and dry weights of aerial parts and roots in both seasons were achieved by 0.75% salinity level plus cultivating in pure sand, pure loam or in the mixture of both at equal parts (1:1). This may be ascribed to lumping the beneficial effect of low and medium salinity on saltbush growth (Mozafar *et al*., 1970 and Matoh *et al*., 1986) and the presence of loam granulars which improve soil texture, structure and fertility, besides increasing capacity of both water holding and cation exchangeable that play a vital role in keeping nutrients from loss with drainage water as induce in the pure sand soil.

These findings are in harmony with those postulated by Mozafar *et al*. (1970) and Sadder (2013) on *Atriplex halimus*, Matoh *et al*. (1986) on *Atriplex gmelini*, Abdel-Fattah *et al*. (2012) on *Ficus retosa* and Shahin *et al*. (2013) on *Ficus benjamina* cv. Samantha and *Schefflera arboricola* cv. Gold Capella.

2- Chemical composition:

Data in Table (8) clear that, chlorophyll a, b and carotenoids content (mg/g f.w.) slightly improved by either soil salinity treatments or media contained loam granulars. However the highest content of the different pigments was attained by the medium level of salinization (1.5%) under the various used media followed by the low salinity level (0.75%) which occupied the second rank in this concern. This result is supported by that of Manousaki and Kalogerakis (2009) whom found that the amount of photosynthetic pigments were increased in the leaves of *Atriplex halimus* plants irrigated with NaCl solution up to 3% concentration. Furthermore, Sadder (2013) reported that photosynthetic activity in the leaves of *A. halimus* was slightly decreased with both extended stress exposure (from 30 h to 70 h) and increased salt concentration (from 150 to 300 and 600 mM NaCl), while total chlorophyll and proline increased under saline stress.

On the other side, the percentages of Na and Ca , as well as Cl (mg/g d.w.) and free proline (µ moles/g d.w.) contents were progressively increased with increasing salinity, but the opposite was the right regarding K%, which descendingly decreased with increasing salinity rate (Tables, 9 and 10). That is because high salinity usually

Table 8. Effect of soil salinity, medium and their interactions on pigments content in the leaves of *Atriplex halimus* L. plants during 2014 season.

Salinity treatments / Medium	Chlorophyll a (mg/g f.w.)						Chlorophyll b (mg/g f.w.)						Carotenoids (mg/g f.w.)					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
Control	0.008	0.011	0.012	0.011	0.011	0.011	0.007	0.009	0.009	0.010	0.080	0.009	0.001	0.003	0.003	0.004	0.003	0.003
0.75% salinity	0.014	0.016	0.015	0.017	0.015	0.015	0.009	0.013	0.012	0.012	0.014	0.012	0.003	0.005	0.006	0.006	0.004	0.005
1.50% salinity	0.016	0.018	0.018	0.017	0.018	0.017	0.011	0.017	0.013	0.014	0.013	0.014	0.003	0.006	0.006	0.007	0.006	0.006
3.00% salinity	0.011	0.013	0.012	0.013	0.011	0.012	0.010	0.011	0.011	0.011	0.010	0.011	0.002	0.004	0.003	0.005	0.004	0.004
Mean	0.012	0.015	0.014	0.015	0.014		0.009	0.013	0.011	0.012	0.011		0.002	0.005	0.005	0.006	0.004	

Table 9. Effect of soil salinity, medium and their interactions on sodium, potassium and calcium content in the leaves of *Atriplex halimus* L. plants during 2014 season.

Salinity treatments / Medium	Na %						K %						Ca %					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
Control	1.12	1.44	1.20	1.38	1.21	1.27	1.72	2.51	2.10	2.79	2.36	2.30	1.40	2.18	1.89	2.08	1.63	1.84
0.75% salinity	1.68	1.76	1.45	1.66	1.48	1.61	1.90	3.18	2.92	3.10	2.49	2.72	1.58	2.57	2.10	2.46	1.97	2.14
1.50% salinity	1.89	2.10	1.79	1.99	1.78	1.91	1.42	2.10	1.87	2.24	1.78	2.27	1.95	3.05	2.65	2.91	1.99	2.51
3.00% salinity	2.26	2.60	2.36	2.47	2.10	2.36	1.33	1.56	1.50	1.43	1.21	1.41	2.30	3.61	3.11	3.42	2.78	3.05
Mean	1.74	1.98	1.70	1.88	1.64		1.59	2.34	2.10	2.39	1.96		1.81	2.85	2.44	2.72	2.09	

Table 10. Effect of soil salinity, medium and their interactions on chloride and free proline content in the leaves of *Atriplex halimus* L. plants during 2014 season.

Salinity treatments \ Medium	Cl (mg/g d.w.)						Free proline (µ moles/g d.w.)					
	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean	Sand (S)	Loam (L)	S + L (1:1)	S + L (1:2)	S + L (2:1)	Mean
Control	1.85	1.99	1.92	2.07	1.56	1.88	1.10	2.70	2.11	2.34	1.87	2.03
0.75% salinity	2.27	2.48	2.34	2.58	1.94	2.32	2.31	5.78	4.40	5.09	3.93	4.30
1.50% salinity	3.98	4.41	3.50	3.79	3.28	3.79	4.85	10.91	9.29	11.32	8.25	8.93
3.00% salinity	6.10	5.38	5.21	5.67	4.68	5.41	10.27	18.47	13.45	18.69	15.32	15.24
Mean	3.55	3.57	3.24	3.53	2.87		4.63	9.47	7.31	9.36	7.34	

leads to increase the uptaking of some highly hydrophilic ions (e.g. Na and borate) as indicated by Handreck and Black (2002). It was also suggested that accumulation of some amino acids and amides in the leaves of salinity stressed-plants may be due to *denovo* synthesis and not the result of protein degradation (Sadder, 2013). The content of Na and Cl was not greatly affect by medium type, whereas content of K, Ca and free proline was markedly increased in the leaves of plants cultivated in pure loam or pure sand amended with loam at any percent. This may be attributed to the role of loam granulars in improving texture, structure and fertility of soil mixture, beside enhancing cation exchange capacity. The interaction between salinity and medium shown variable responses, as the highest content of Na and K was mostly achieved by either low (0.75%) or medium (1.5%) salinity level under loam or sand + loam media, while the highest content of Ca , Cl and proline was noticed in plants cultured in loam and sand + loam media salinized with the high salinity rate (3.0%).

Analogous observations were also obtained by Mozafar *et al*. (1970) on *Atriplex halimus*, Matoh *et al*. (1986) on *Atriplex gmelini*, Al-Qubaie *et al*. (2003) on *Ficus benghalensis, Tamarix articulata, Jasminum azoricum, Conocarpus erectus and Ziziphus spina-christi* and Shahin *et al*. (2008) on *Ficus macrocarpa* var. Hawaii and *Euonymus joponicus* cv. Aureus.

It appears from the previous gains that Mediterranean saltbush (*Atriplex halimus* L.) plants can grow well in the loam or sand amended with loam salinized with NaCl + $CaCl_2$ (1:1 w/w) at medium and low levels.

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استجابة نباتات شجيرة الملح (القطف) لملوحة ونوع بيئة النمو

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أجريت تجربة أصص تحت الشمس الساطعة بحديقة الأورمان النباتية، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي ٢٠١٣، ٢٠١٤ لدراسة تأثير الزراعة فى بيئات مختلفة، هى: الرمل، الطمي ومخلوط الرمل والطمي بنسبة ١:١، ١: ٢، ٢: ١ (بالحجم) والتي تم تمليحها بمخلوط متساوي من أملاح كلوريد الصوديوم وكلوريد الكالسيوم (١ : ١ بالوزن) بتركيزات صفر، ٠.٧٥، ١.٥، ٣ % على النمو والتركيب الكيميائي لشتلات عمر ستة أشهر من شجيرة الملح المعروفة محلياً باسم القطف (*Atriplex halimus* L.) والمنزرعة فى أصص فخار قطرها ٤٠ سم مملوءة بوزن معلوم من البيئات المختلفة سالفة الذكر.

أوضحت النتائج المتحصل عليها أن جميع قياسات النمو الخضري والجذري قد تحسنت معنوياً بالمستويات المنخفضة والمتوسطة من الملوحة (٠.٧٥، ١.٥ %، على الترتيب)، مع تفوق المستوى المنخفض (٠.٧٥ %) والذي أعطى أعلى المتوسطات لمختلف قياسات النمو باستثناء صفة مساحة الورقة والتي وصلت إلى أعلى القيم بالتركيز المتوسط من الملوحة (١.٥ %) مقارنة بالكنترول ومعاملات الملوحة الأخرى بكلا الموسمين. أما التركيز المرتفع من الملوحة (٣ %) فقد أحدث انخفاضا معنوياً فى جميع قياسات النمو الخضري والجذري لتصل إلى أدنى القيم مقارنة بالكنترول فى معظم الحالات بكلا الموسمين. ولقد أعطى مخلوط الرمل + الطمي، خاصة بنسبة ١ : ٢ أو ٢ : ١ أفضل تحسناً فى قياسات النمو الخضري والجذري مقارنة بجميع بيئات النمو الأخرى فى كلا الموسمين. كذلك أعطى التفاعل بين مخاليط الرمل والطمي الثلاثية المستخدمة بهذه الدراسة والتمليح بالتركيز المنخفض (٠.٧٥ %) أطول النباتات، أكثر السيقان سمكاً وأعلى عدد للأفرع والأوراق/نبات فى كلا الموسمين، بينما أثقل الأوزان الطازجة والجافة للنموات الخضرية والجذور سجلها تركيز الملوحة المنخفض (٠.٧٥ %) للنباتات التى زرعت إما فى الرمل الخالص أو الطمي الخالص أو فى مخلوط متساوي بينهما (١ : ١).

أظهرت النتائج أيضاً حدوث تحسن طفيف فى محتوى الأوراق من كلوروفيللي أ، ب والكاروتينويدات سواء بمعاملات تمليح التربة أو بالزراعة فى البيئات المحتوية على حبيبات الطمي (المخاليط). على الجانب الأخر، فإن محتوى الصوديوم، الكالسيوم، الكلوريد، البرولين بالأوراق قد زاد بشكل تصاعدي بزيادة تركيز الملوحة، لكن العكس كان صحيحاً فيما يتعلق بمحتوى البوتاسيوم والذي انخفض تنازلياً بزيادة تركيز الملوحة. لم يتأثر محتوى الصوديوم والكلوريد كثيراً بنوع البيئة، بينما زاد محتوى البوتاسيوم، الكالسيوم والبرولين بشكل ملحوظ فى أوراق النباتات المنزرعة فى الطمي فقط أو الرمل المدعوم بأي نسبة من الطمي. وأيضاً أظهرت معاملات التفاعل تأثيرات متفاوتة على المكونات الكيميائية بالأوراق، حيث تحقق أعلى محتوى من الصوديوم والبوتاسيوم بالجمع بين التمليح بالتركيز المنخفض أو المتوسط والزراعة فى الطمي أو مخلوط الرمل والطمي (بأي نسبة)، بينما أحرز التفاعل بين التمليح بالتركيز المرتفع (٣ %) والزراعة فى بيئة الطمي أو مخلوط الرمل والطمي (بأي نسبة) أعلى محتوى من الكالسيوم، الكلوريد والبرولين.

وعليه؛ يتضح من النتائج السابقة أن نباتات شجيرة الملح تستطيع النمو بشكل جيد فى بيئة الطمي أو الرمل المدعوم بالطمي والمملحة بمخلوط متساوي من أملاح كلوريد الصوديوم وكلوريد الكالسيوم بتركيز لا يزيد عن ١.٥ %.