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Morphological and Physiological Responses of Silvery (*Leucophyllum frutescens*) to Water Deficient and Irrigation Water Salinity Stresses

H.A. Ashour and A.B. El-Attar

Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt

Abstract: In order to investigate the stress impact of water deficient and irrigation water salinity on *Leucophyllum frutescens* plants, pots experiment was conducted at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2014/2015 and 2015/2016. Water deficient stress was imposed by different irrigation intervals of 4, 7, 10 and 13 days using tap water (control, 270 ppm) or saline water at concentration of 1000, 2000, 4000, 6000 or 8000 ppm for imposing salinity stress. The concentrations of saline water were prepared by addition of NaCl and $CaCl_2$ to tap water with equal proportion and the plants were irrigated till 100% of soil field capacity at each irrigation interval. The results showed that both water deficient and salinity stress reduced survival percentage, vegetative growth and flowering parameters (plant height, number of branches/plant, stem diameter, leaf area, root length, number of flowers/plant as well as fresh and dry weights of stems, leaves, roots and flowers). In most cases, the reduction in survival percentage and most of growth and flowering parameters was significant as irrigation intervals was prolonged to 10 or 13 days compared to irrigation every 4 days. The reduction in survival percentage was significant with using saline water at concentrations of 4000-8000 ppm, while using salt concentrations of 2000-8000 ppm, in most cases, significantly reduced most of growth and flowering parameters compared to control. Leaves chemical constituents of total chlorophylls, total carbohydrates, N, P and K % were decreased in response to both water deficient and salinity stress. Total chlorophylls, P and K % were decreased significantly as irrigation intervals was prolonged to 10 or 13 days, while the reduction in N % was significant when irrigation intervals was prolonged to 13 days, compared to irrigation every 4 days. Total carbohydrates, P and K % were reduced significantly as a result of using saline water at concentrations of 2000-8000 ppm, while the reduction in total chlorophylls and N % were significant as a result of using saline water at concentrations of 3000-8000 ppm compared to control. On the other hand, Na, Cl % and proline content in leaves were increased in response to water deficient and salinity stress. The increase in Na, Cl % was significant as irrigation intervals prolonged to 13 days compared to irrigation every 4 days. Na, Cl and Ca% were increased significantly with raising salt concentration in irrigation water from 2000-8000 ppm, while the increase in proline content was significant with using salt concentration of 4000-8000 ppm compared to control. The interaction between the two studied factors showed that, the reduction in most of the growth and flowering parameters as well as total carbohydrates percentage was insignificant in plants irrigated every 7 or 10 days with using tap water or in plants irrigated every 4 days using a salt concentration of 1000 or 2000 ppm. Also, the accumulation of Na and Cl toxic ions was insignificant in plants irrigated every 7 or 10 days with using tap water or in plants irrigated every 4, 7 or 10 days using salt concentration of 1000 or 2000 ppm, compared to plants irrigated every 4 days using tap water (unstressed control plants). Based on the obtained results it can be concluded that, *Leucophyllum frutescens* can be irrigated every 10 days using tap water, or every 4 days using saline water with concentrations up to 2000 ppm, without any significant reduction in most of the vegetative growth and flowering parameters.

Key words: *Leucophyllum frutescens* · Water deficient stress · Irrigation water salinity stress

Corresponding Author: H. A. Ashour, Department of Ornamental Horticulture, Faculty of Agriculture, Cairo University, Giza, Egypt.

INTRODUCTION

Leucophyllum frutescens (Berl) I.M. Johnst., is an evergreen shrub belongs to the family of Scrophulariaceae. It is native to Texas and Mexico but now widely cultivated in Florida and South East Asia. It is commonly known as silvery, Texas Ranger, Texas sage, barometer brush, cenizo, silver leaf, purple sage and white sage. Although it is called sage but has no relationship to the genus saliva. Plants are reaching 2-2.5 m high and 1.5-2 m wide, with spherical crown and used as a clipped hedge, or as an informal specimen in a desert landscape. The leaves are 1-3.5 cm long and 0.4-1.6 cm wide, simple, elliptic to ovate with entire margins, silvery to gray-green in color, roofed with silver pubescence. The flowers are measure up to 26 mm in length and width, violet or purple, sometimes pink in color, borne singly in crowded leaf axils, they are bell- or funnel-shaped with five lobes. Flowering season generally runs from June through late summer and early fall. The fruit is small capsule of brown color having small wrinkled seeds [1, 2]. Additionally, the plants uses for landscape activates as a flowering ornamental shrubs, plant flowers has been recommended as a medicinal plant for treating tuberculosis, bronchitis, diarrhea, damage of the liver [3].

In Egypt, as one country of arid and semi-arid regions, landscape activities of new cities, coastal resorts and touristic villages are commonly built in desert areas as scarcity of freshly water resources where irrigation depends primarily on alternative sources of relatively saline water from wells or desalination units. The use of salt and drought-tolerant specious for landscape and garden projects in such areas is one of the most important agriculture practical approaches for ensure vigorous growth and maintain a normal appearance. Although, similarly responses of plants to water deficient and salt stress, however some halophytes can tolerate salt stress but not drought and some xerophytes can tolerate drought but not salt stress [4]. Therefore, it is necessary to screen drought and salt tolerance of plants used in urban landscapes for appropriately recommendations on plant selection.

Water deficient or drought and salinity are common abiotic stresses that limiting growth and productivity of plants as they cause low water availability for plants and effect on plant growth through its effect on physiological and biochemical processes such as photosynthesis, respiration, hormones balance, absorption of minerals, inhibition of enzymatic activates and change in protein and nucleic metabolism [5]. In drought and salt-stressed plants, the diffusion of CO_2 is decreased which decreased photosynthesis [6]. Drought and salinity reduced leaf water potential, stomatal conductance and transpiration [7]. In addition to ion toxicity under salinity, they cause nutritional imbalance [8]. Moreover, increased reactive oxygen species under water deficient and salt stress which leading to oxidative damage to different cell constituents [9]. Drought and salt tolerance of plants varies greatly with species and even cultivars within a species. Plants use various strategies to overcome the adverse effects of osmotic and ionic stresses caused by water deficient and salinity such as accumulation of proline and other osmotic adjusting substances. Plants adapt to salinity by Na^+ and Cl^- exclusion, or limited accumulation of Na^+ and Cl^- in plant tissues [10, 11]. Drought resistant plants manage to reduce water loss by increased stomatal resistance and increased water uptake through extensive root system [12].

The interactive studies of water deficient and salt stress may give the true picture of the plant's performance under conditions of many places in which drought and salinity occur together [13]. Many of the previous studies have been carried out on the interaction between the both factors and its effect on morphological and physiological characteristics of different ornamental plants and the results showed morphological change in growth and flowering parameters [14, 15], physiological and biochemical changes such as reductions in total chlorophyll and increasing in proline content [16, 17], reduction in uptake and accumulation nutrients [18] and accumulation of Na^+ or Cl^- on plant organs of stressed plants [19].

Silvery is one of ornamental shrubs that take a great interest in landscape activates in recent years. However, the available researches about its responses to drought or salt stress are limited. Therefore, the aim of this research was to evaluate the effects of different levels of water shortage and irrigation water salinity on growth, flowering and chemical compositions of *Leucophyllum frutescens* plants to detect the morphological and physiological response underlying the plants tolerance to drought and salinity.

MATERIALS AND METHODS

This study was carried out in the experimental nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, during the

Table 1: The physical and chemical characteristics of soil mixture used for growing *Leucophyllum frutescens* during 2014/2015 and 2015/2016 seasons

Physical characteristics								
Field capacity (% V)			Clay (%)		Coarse sand (%)	Fine sand (%)	Silt(%)	Soil texture
29.58			3.4		35.7	53.4	7.5	sandy
Chemical characteristics								
Macro-nutrients (ppm)								
N	P	K	Mg	PH	Organic matter (%)	EC (dS/m)	CEC (meq/100 g)	$CaCO_3$ (%)
29.17	9.17	62.78	33.98	7.12	3.17	2.75	19.64	2.44

two successive seasons of 2014/2015 and 2015/2016. The purpose of the work was to investigate the stress effect of water deficient and irrigation water salinity on growth, flowering and chemical compositions of *Leucophyllum. frutescens* plants.

On 15th March, in both seasons, seedlings of *Leucophyllum frutescens* plants were obtained from a commercial nursery with an average plant height of 25 cm and planted individually in 30 cm diameter plastic pots filled with 10 kg of the mixture of sand + compost (3:1: v/v), The physical and chemical characteristics of used soil mixture are presented in Table 1.

The seedlings were allowed to stand for 15 days as recovery period. In both seasons, treatments were initiated in first week of April, the plants were irrigated every 4, 7, 10 or 13 days for imposing water stress using tap water (control, 270 ppm) or saline water at concentration of 1000, 2000, 4000, 6000 or 8000 ppm for imposing salinity stress. The different saline water concentrations were prepared using a mixture of NaCl and $CaCl_2$ (1:1 w/w). At each irrigation, the plants were watered till 100% of soil field capacity (F.C.). The soil moisture tension was measured before each irrigation using microtensiometers and the quantity of water needed to reach 100% field capacity was calculated [20]. All the plants were received soluble chemical fertilizer life green (NPK, 20-20-20), which applied monthly at the rate of 2.5 g/pot, also common agricultural processes such as hand picking of weeds were performed.

The layout of the experiment was a split-plot design in a randomized complete blocks with 24 treatments [4 irrigation intervals X 6 salt concentrations (including the control)], with 4 blocks (replicates), each block consisting of 72 plants (3 plants/treatment). Irrigation intervals were assigned to the main plots, while irrigation water salinity treatments were assigned to the sub-plots and were assigned randomly under each irrigation intervals.

At the end of the experiment, on 30th February in first seasons and 10st March in the second one, the parameters were recorded including survival percentage (expressed as the number of living plants in relation to the number of tested plants), vegetative growth parameters including plant height (cm), number of branches/plant, stem diameter (mm, at 5 cm above soil surface), leaf area (cm^2), root length (cm), as well as fresh and dry weights of leaves, stems and roots/plant. Also, flowering characteristics including number of flowers/plant (determined three times during flowering season and the average of mean values were recorded), fresh and dry weights of flowers (g/ plant) were also recorded. In addition, total chlorophylls in fresh leaf samples were determined by using chlorophyll meter Model SPAD 502 [21]. The total carbohydrates content (% of dry matter) was determined in dried leaves samples [22]. Dried leaves samples were digested to extract nutrients [23] and the extract was chemically analyzed to determine its contents of nitrogen, phosphorus, potassium, sodium, calcium and chloride contents [24, 25]. The proline content in fresh leaves (µ moles/g fresh matter of leaves) was also determined [26]. The data recoded on vegetative growth, flowering and chemical constituents were subjected to an analysis of variance (ANOVA) and the means of the recorded data were compared using the "Least Significant Difference (LSD)" test at the 0.05 level [27].

RESULTS AND DISCUSSION

Survival Percentage: It is evident from data in Table 2 that irrigation intervals had adverse effect on the survival percentage of *Leucophyllum frutescens* plants. In both seasons, the mean values of the survival percentage were reduced in parallel with prolonged irrigation intervals from 4 to 7, 10 or 13 days. However, this reduction was insignificant when the irrigation intervals were prolonged from 4 to 7 days, whereas prolonged irrigation intervals up to 10 or 13 days resulted in significant reductions in the survival percentage, compared to the values recorded with irrigation every 4 days. Similar reduction in the survival percentage as a result of water deficient stress was obtained by many studies [28-30].

Table 2: Effect of irrigation intervals and irrigation water salinity on survival percentage, plant height, number of branches/plant, stem diameter and leaf area of *Leucophyllum frutescens* during the 2014/2015 and 2015/2016 seasons.

	First season (2014/2015)					Second season (2015/2016)				
	Irrigation intervals (I)					Irrigation intervals (I)				
Salt concentration (S), ppm	4 days	7 days	10 days	13 days	Mean (S)	4 days	7 days	10 days	13 days	Mean (S)
					Survival percentage					
Control	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.7	97.9
4000	100.0	100.0	91.7	91.7	95.8	100.0	91.7	91.7	91.7	93.8
6000	100.0	91.7	91.7	83.4	91.7	100.0	91.7	83.4	83.4	89.6
8000	83.4	83.4	75.0	75.0	79.2	83.4	83.4	83.4	75.0	81.3
Mean (I)	97.2	95.8	93.1	91.7	----	97.2	94.5	93.1	90.3	----
L.S.D. (0.05)										
I	3.9					4.1				
S	4.2					5.1				
I X S	9.1					10.1				
					Plant height (cm)					
Control	99.20	92.75	84.08	73.15	87.29	94.40	89.10	82.73	62.65	82.22
1000	98.13	90.98	81.23	72.63	85.74	90.68	87.00	74.58	71.20	80.86
2000	91.50	90.55	79.33	71.28	83.16	88.50	85.85	71.60	64.70	77.66
4000	75.68	77.40	71.23	66.50	72.70	67.60	66.00	67.65	63.75	66.25
6000	67.88	69.28	73.50	55.65	66.58	64.60	64.05	59.75	58.20	61.65
8000	57.28	52.83	60.00	50.30	55.10	47.00	49.65	48.15	43.20	47.00
Mean (I)	81.61	78.96	74.89	64.92	----	75.46	73.61	67.41	60.62	----
L.S.D. (0.05)										
I	3.33					2.61				
S	4.07					3.20				
I X S	8.15					6.39				
					Number of branches/plant					
Control	10.73	10.20	9.84	6.95	9.43	10.80	9.80	10.23	7.70	9.63
1000	9.18	7.81	7.67	7.73	8.10	10.26	7.90	7.87	7.84	8.47
2000	8.65	7.63	7.18	6.69	7.54	9.06	8.04	7.80	7.19	8.02
4000	7.83	7.34	7.28	7.27	7.43	7.90	6.94	7.29	7.05	7.29
6000	7.28	6.53	6.58	6.44	6.71	6.91	6.47	6.09	6.07	6.38
8000	6.02	5.16	5.15	5.11	5.36	5.38	5.63	5.97	4.83	5.45
Mean (I)	8.28	7.44	7.28	6.70	----	8.38	7.46	7.54	6.78	----
L.S.D. (0.05)										
I	1.10					1.12				
S	1.34					1.37				
I X S	2.68					2.75				
					Stem diameter (mm)					
Control	8.58	6.83	6.78	6.05	7.06	8.05	7.40	6.88	4.90	6.80
1000	7.85	6.48	6.28	5.08	6.42	6.88	6.05	5.81	5.48	6.06
2000	7.35	6.23	5.53	5.13	6.06	6.49	6.03	5.97	5.27	5.94
4000	6.28	5.93	6.28	4.90	5.84	5.93	5.50	5.46	5.45	5.59
6000	5.23	5.10	5.45	5.30	5.27	5.46	4.90	4.88	4.83	5.02
8000	4.33	4.75	4.80	4.58	4.61	3.66	4.13	4.13	3.42	3.84
Mean (I)	6.60	5.88	5.85	5.17	----	6.08	5.67	5.52	4.89	----
L.S.D. (0.05)										
I	0.82					0.77				
S	1.01					0.95				
I X S	2.01					1.89				
					Leaf area (cm^2)					
Control	4.92	4.87	4.77	3.53	4.52	4.80	4.56	4.53	3.05	4.23
1000	4.76	4.46	4.16	3.64	4.25	4.54	4.46	3.47	3.58	4.01
2000	4.72	4.34	4.23	3.62	4.23	4.53	4.17	3.50	3.43	3.91
4000	4.01	3.81	3.61	3.34	3.69	3.27	3.28	3.22	3.11	3.22
6000	3.60	3.63	3.73	2.88	3.46	3.31	3.16	2.75	2.93	3.04
8000	2.66	2.77	2.82	2.39	2.66	2.23	2.41	2.35	2.13	2.28
Mean (I)	4.11	3.98	3.89	3.23	----	3.78	3.67	3.30	3.04	----
L.S.D. (0.05)										
I	0.15					0.12				
S	0.19					0.14				
I X S	0.38					0.28				

Table 3: Effect of irrigation intervals and irrigation water salinity on fresh and dry weights of stems and leaves as well as root length of *Leucophyllum frutescens* during the 2014/2015 and 2015/2016 seasons

	First season (2014/2015)					Second season (2015/2016)				
	Irrigation intervals (I)					Irrigation intervals (I)				
Salt concentration (S), ppm	4 days	7 days	10 days	13 days	Mean (S)	4 days	7 days	10 days	13 days	Mean (S)
					Fresh weight of stems (g/plant)					
Control	82.98	72.10	71.30	70.63	74.25	91.59	75.13	75.61	69.67	78.00
1000	72.63	70.88	70.78	63.08	69.34	85.79	72.11	65.86	60.44	71.05
2000	72.10	69.65	64.73	56.00	65.62	79.74	72.89	67.46	53.26	68.34
4000	60.85	59.30	56.88	54.35	57.84	54.25	60.10	64.81	49.14	57.07
6000	57.28	56.55	55.10	42.88	52.95	44.90	55.00	40.54	42.91	45.84
8000	49.88	45.88	51.10	41.33	47.04	44.64	43.32	48.13	39.63	43.93
Mean (I)	65.95	62.39	61.65	54.71	----	66.82	63.09	60.40	52.51	----
L.S.D. (0.05)										
I	4.93					7.49				
S	6.04					9.17				
I X S	12.08					18.34				
					Dry weight of stems (g/plant)					
Control	29.66	27.17	26.12	21.44	26.10	32.51	29.99	27.64	22.30	28.11
1000	26.41	25.15	24.96	21.14	24.41	30.78	24.87	23.36	22.93	25.48
2000	26.24	24.32	23.50	21.39	23.86	29.25	24.49	23.74	19.99	24.37
4000	20.35	19.38	21.92	23.33	21.24	15.45	17.51	19.87	13.41	16.56
6000	15.91	15.69	14.50	12.49	14.65	14.31	13.92	11.30	13.46	13.25
8000	14.23	12.78	13.50	11.10	12.90	13.02	12.59	13.94	8.39	11.98
Mean (I)	22.13	20.75	20.75	18.48	----	22.55	20.56	19.97	16.75	----
L.S.D. (0.05)										
I	1.68					2.88				
S	2.05					3.53				
I X S	4.11					7.06				
					Fresh weight of leaves (g/plant)					
Control	50.37	48.62	42.07	47.21	47.07	60.25	50.62	50.96	46.50	52.08
1000	47.41	40.65	39.46	49.20	44.18	57.52	43.12	44.84	40.58	46.52
2000	45.22	41.38	36.02	37.10	39.93	55.49	46.05	43.56	38.40	45.87
4000	38.68	38.02	35.97	30.55	35.80	36.90	41.21	42.82	34.02	38.73
6000	42.95	36.07	36.21	26.82	35.51	32.36	37.79	27.31	29.31	31.69
8000	36.47	36.08	25.64	22.77	30.24	30.21	29.46	32.71	31.15	30.88
Mean (I)	43.52	40.13	35.89	35.61	----	45.45	41.37	40.36	36.66	----
L.S.D. (0.05)										
I	3.83					4.71				
S	4.69					5.77				
I X S	9.37					11.55				
					Dry weight of leaves (g/plant)					
Control	14.53	13.87	12.17	11.27	12.96	18.16	17.97	14.75	13.68	16.14
1000	13.76	11.08	10.59	11.11	11.63	17.40	14.17	13.64	12.35	14.39
2000	12.40	11.20	10.09	9.90	10.90	15.49	13.64	10.90	9.60	12.40
4000	11.08	11.18	9.60	8.51	10.09	13.14	13.75	12.69	9.15	12.18
6000	12.50	10.37	9.69	7.25	9.95	10.05	9.60	6.65	7.31	8.40
8000	9.72	9.02	6.98	5.82	7.88	8.08	7.70	7.76	6.83	7.59
Mean (I)	12.33	11.12	9.85	8.97	----	13.72	12.80	11.06	9.82	----
L.S.D. (0.05)										
I	1.27					1.58				
S	1.56					1.93				
I X S	3.11					3.87				
					Root length (cm)					
Control	20.06	19.99	17.70	15.80	18.38	24.77	21.09	20.85	16.40	20.78
1000	19.04	16.11	15.62	16.14	16.73	24.59	19.15	18.00	15.99	19.43
2000	17.43	16.23	16.37	14.18	16.05	23.08	18.58	15.88	13.82	17.84
4000	16.36	14.97	12.64	13.54	14.37	18.84	18.27	18.66	14.39	17.54
6000	15.28	15.66	15.98	13.54	15.11	18.06	17.97	16.66	14.07	16.69
8000	14.25	14.05	13.27	12.10	13.42	17.42	17.17	14.73	13.77	15.77
Mean (I)	17.07	16.17	15.26	14.22	----	21.13	18.70	17.46	14.74	----
L.S.D. (0.05)										
I	1.37					2.29				
S	1.68					2.81				
I X S	3.37					5.61				

Table 4: Effect of irrigation intervals and irrigation water salinity on fresh and dry weights of roots/plant, number of flowers/plant as well as fresh dry weights of flowers of *Leucophyllum frutescens* during the 2014/2015 and 2015/2016 seasons.

	First season (2014/2015)					Second season (2015/2016)				
	Irrigation intervals (I)					Irrigation intervals (I)				
Salt concentration (S), ppm	4 days	7 days	10 days	13 days	Mean (S)	4 days	7 days	10 days	13 days	Mean (S)
					Fresh weight of roots (g/plant)					
Control	78.28	68.25	66.08	64.93	69.38	82.51	70.59	71.59	65.73	72.60
1000	76.45	64.43	61.39	61.79	66.01	81.70	64.25	62.55	52.97	65.37
2000	70.19	60.97	56.01	48.28	58.86	71.84	62.58	58.15	43.30	58.97
4000	59.37	58.16	57.36	54.08	57.24	42.72	52.72	55.01	45.08	48.88
6000	55.63	59.29	48.83	47.11	52.72	43.42	42.64	37.54	37.49	40.27
8000	40.15	39.35	43.17	35.50	39.54	40.95	35.22	34.72	28.31	34.80
Mean (I)	63.34	58.41	55.47	51.95	----	60.52	54.67	53.26	45.48	----
L.S.D. (0.05)										
I	5.48					6.56				
S	6.71					8.03				
I X S	13.43					16.07				
					Dry weight of roots (g/plant)					
Control	26.90	24.42	23.59	19.42	23.58	29.26	25.56	25.19	22.64	25.66
1000	25.25	22.05	20.48	17.99	21.44	28.32	22.61	23.08	16.92	22.73
2000	25.63	22.28	19.96	15.78	20.91	25.78	20.80	16.85	14.88	19.58
4000	21.25	19.53	19.51	15.58	18.97	15.04	20.31	17.18	14.83	16.84
6000	18.03	18.64	14.40	14.11	16.29	15.18	14.60	11.88	13.24	13.73
8000	15.51	15.22	11.54	12.73	13.75	15.27	13.34	10.80	9.57	12.24
Mean (I)	22.09	20.36	18.25	15.93	----	21.47	19.54	17.50	15.34	----
L.S.D. (0.05)										
I	1.80					2.58				
S	2.21					3.16				
I X S	4.42					6.32				
					Number of flowers/plant					
Control	21.62	20.25	19.67	15.96	19.37	28.38	26.85	24.16	19.13	24.63
1000	19.65	16.17	16.08	15.77	16.92	25.47	22.67	22.71	18.93	22.44
2000	18.94	16.08	15.30	14.12	16.11	26.73	22.53	18.50	15.92	20.92
4000	15.84	15.58	14.17	14.09	14.92	21.18	18.80	19.73	16.34	19.01
6000	15.81	14.58	11.89	14.09	14.09	19.77	17.66	13.38	13.37	16.05
8000	12.51	10.44	11.06	10.19	11.05	11.14	14.31	11.78	10.47	11.92
Mean (I)	17.39	15.51	14.69	14.04	----	22.11	20.47	18.37	15.69	----
L.S.D. (0.05)										
I	2.16					2.11				
S	2.65					2.58				
I X S	5.30					5.17				
					Fresh weight of flowers (g/plant)					
Control	8.69	7.84	7.52	6.54	7.64	12.92	12.89	12.17	9.41	11.85
1000	7.26	6.54	6.40	6.14	6.58	12.16	10.27	10.21	9.97	10.65
2000	6.85	6.47	6.35	5.94	6.40	10.57	9.96	8.37	7.92	9.21
4000	6.17	6.02	6.32	5.70	6.05	7.99	8.05	8.44	7.44	7.98
6000	5.64	5.58	5.05	5.44	5.43	7.40	5.83	5.76	4.69	5.92
8000	4.70	4.66	4.77	4.01	4.53	5.52	5.91	5.87	3.95	5.32
Mean (I)	6.55	6.18	6.07	5.63	----	9.43	8.82	8.47	7.23	----
L.S.D. (0.05)										
I	0.88					1.06				
S	1.08					1.30				
I X S	2.15					2.60				
					Dry weight of flowers (g/plant)					
Control	3.50	3.30	2.56	2.16	2.88	5.54	4.81	4.76	3.90	4.75
1000	2.80	2.83	2.55	2.43	2.65	4.94	4.20	4.25	3.40	4.20
2000	2.65	2.28	2.20	2.33	2.36	4.47	3.46	3.78	3.28	3.75
4000	2.51	2.31	2.27	2.17	2.31	3.32	3.47	2.41	3.19	3.10
6000	2.35	2.27	1.75	1.94	2.07	2.05	2.20	2.07	1.20	1.88
8000	1.64	1.71	1.79	1.68	1.70	1.28	2.15	1.76	1.15	1.58
Mean (I)	2.57	2.45	2.19	2.12	----	3.60	3.38	3.17	2.69	----
L.S.D. (0.05)										
I	0.39					0.46				
S	0.48					0.56				
I X S	0.95					1.13				

Concerning the survival percentage as affected by irrigation water salinity, the data in Table 2 indicate that the survival percentage was decreased steadily as a result of increasing salt concentration in irrigation water from 1000 to 8000 ppm compared to the control (without adding any salt concentration). The reduction in mean values of survival percentage was insignificant, in both seasons, with raising the salt concentration in the irrigation water from 1000 to 2000 ppm, while increasing salt concentration from 4000 - 8000 ppm significantly reduced the survival percentage compared to the control. The reduction of the survival percentage as a result of increasing salt stress is in agreement with the results reported by previous studies [31- 37].

The reduction in the survival percentage with either long irrigation intervals or high salt concentration may be due to their effects on osmotic inhibition of water absorption, in addition to ions toxicity by high Na^+ and Cl^- accumulations in leaves, which caused salt damage and eventually plant death as salinity in the root zone increased [37, 38].

Regarding the interaction effects between irrigation intervals and salt concentrations treatments, the data recorded in Table 2 show that in both seasons, within each of the tested irrigation intervals, plants irrigated with saline water at concentrations up to 4000 ppm showed no significant reduction in the survival percentage compared to plants irrigated with tap water. In addition to, the reduction in the survival percentage was also insignificant in plants irrigated with saline water at concentrations of 6000 ppm every 4, 7 or 10 days (in the first season) or every 4 or 7 days (in the second one) compared to irrigation with tap water. However, irrigation with the highest salt concentration (8000 ppm) with each of the tested irrigation intervals resulted in significant reduction in the survival percentage with no significant differences compared to each other's.

Vegetative Growth and Flowering Parameters

Effect of Irrigation Intervals: Data recorded on *Leucophyllum frutescens* plants Tables 2-4 show that the different growth and flowering parameters were considerably affected by irrigation intervals. In both seasons, all the studied growth and flowering parameters were reduced steadily with prolonged irrigation intervals daily from 4 to 7, 10 or 13 days. In both seasons, in most cases, prolonged irrigation intervals from 4 to 7 days caused only a slight (insignificant) reduction in most of the studied parameters (including plant height, leaf area, root length, fresh and dry weights of leaves and roots as well as number of flowers/plant), whereas prolonged irrigation intervals up to 10 or 13 days resulted in significant reductions in the recorded mean values, compared to the values recorded with the short intervals (4 days). The reduction in number of branches/plant, stem diameter as well as fresh and dry weights of stems and flowers was insignificant as irrigation intervals prolonged from 4 to 7 or 10 days, whereas the longest intervals (13 days) caused significant reductions in the recorded mean values, compared to the values recorded with irrigation every 4 days, with no significant differences between irrigation every 7 or 10 days. The results of reductions in the growth and flowering parameters as a result of water deficient stress are concordant with those obtained by prior researches [39- 48].

Effect of Irrigation Water Salinity: Data presented in Tables 2 – 4 indicate that salt concentrations in irrigation water had also an adverse effect on growth and flowering parameters of *Leucophyllum frutescens* plants. In both seasons, increasing salt concentration from 1000 to 2000, 4000, 6000 or 8000 ppm resulted in steady reduction in all of studied growth and flowering parameters compared to the control plants. In most cases, the reduction in the recorded mean values for most of the studied parameters was insignificant with the lowest salt concentration (1000 ppm), whereas irrigation with higher salt concentrations (2000 - 8000 ppm) resulted in significant reduction in the mean values compared to the control. The reduction in stem diameter was insignificant as raising salt concentrations in the irrigation water up to 2000 ppm. Leaf area was significantly reduced even with the lowest salt concentration (1000 ppm) as compared to the control. Similar reductions in growth and flowering parameters as a result of raising salt stress have been obtained by various researches [33, 49- 56].

The reduction in growth and flowering parameters in response to water deficient and salt stress may be due to the adverse effect of the two factors on osmotic stress and water availability around the roots. Low soil moisture availability due to water stress and low soil osmotic potentials due to salt stress lead to decrease water and nutrients absorption by roots, in addition to ionic toxicity, nutritional imbalance and oxidative damages in cellular compounds [9, 10], this leading to reduction in vegetative biomass which consequently followed by decreasing number of flower/plant as well as fresh and dry weights of flower.

Interaction Effects Between Irrigation Intervals and Irrigation Water Salinity: The data presented in two seasons Tables 2-4 indicate that, in most cases, most of the studied growth and flowering parameters of *Leucophyllum frutescens* plants was decreased steadily as a result of prolonged irrigation intervals and/or increasing the salt concentration in irrigation water, compared to unstressed control plants (plants irrigated every 4 days with using tap water) which resulted the highest mean values. On the other hand, the lowest mean values were obtained from plants irrigated with the longest intervals (13 days) using irrigation water with the highest salt concentration (8000 ppm). Also from the data in Tables 2 - 4 it can be noticed that in most cases, the reduction in the values recorded for most of the studied growth and flowering parameters was insignificant in plants irrigated every 7 or 10 days using tap water or in plants irrigated every 4 days using salt concentration of 1000 or 2000 ppm compared to unstressed control plants. The reduction in growth and flowering parameters as a result of increasing water stress and/or salinity levels is in agreement with findings of previous studies [15-17, 19, 57-58].

Chemical Constituents

Total Chlorophylls Content: As shown in Table 5, the data reveal that irrigation intervals had an adverse effect on the synthesis of total chlorophylls content in leaves of *Leucophyllum frutescens* plants. In both seasons, total chlorophylls content was reduced in parallel with prolonged irrigation intervals from 4 to 7, 10 or 13 days. Accordingly, the highest mean values were obtained from plants irrigated at the shortest intervals (4 days), whereas the lowest values were obtained from plants irrigated at the longest intervals (13 days). In both seasons, the reduction in recorded means values was insignificant as a result of prolonged irrigation intervals daily from 4 to 7 days, whereas prolonged irrigation intervals up to 10 or 13 days resulted in significant reductions in total chlorophylls content, compared to the values recorded with irrigation every 4 days, with no significant difference between irrigation every 10 or 13 days. Similar reductions in total chlorophylls content as a result of water deficient stress were reported by various studies [39, 41, 43, 45- 47].

Data presented in Table 5 indicate that total chlorophylls content was also adversely affected by irrigation water salinity. In both seasons, raising the salt concentration in irrigation water from 1000 to 8000 ppm caused a steady reduction in the total chlorophylls content compared to the control. The reduction in the recorded mean values, in both seasons, was statistically insignificant as a result of irrigation with saline water at the lower concentrations (1000 - 2000 ppm), whereas irrigation with saline water at the higher concentrations (4000 - 8000 ppm) significantly reduced the recorded mean values compared to the control. The reduction of total chlorophylls content as a result of raising the salt concentration in irrigation water is in agreement with the results reported by previous studies [49, 51, 53- 55, 59].

Regarding the interaction effects between irrigation intervals and salt concentrations treatments, the data recorded in Table 5 indicate that, within each concentration of water salinity treatment, in most cases, prolonged irrigation intervals resulted in steady reduction in total chlorophylls content, compared to irrigation every 4 day (no water stress). Within each irrigation intervals treatment, in most cases, raising salt concentration in irrigation water resulted in steady reduction in total chlorophylls content compared to irrigation with tap water (no salt stress). The data in Table 5 also reveal that the reduction in total chlorophylls content was insignificant in plants irrigated every 7 days using tap water or in plants irrigated every 4 days using saline water at concentration of 1000 or 2000 ppm, compared to unstressed control plants (plants irrigated every 4 days using tap water). The reduction in total chlorophylls content as a result of combining water stress and salinity stress are in agreement with findings of other studies [16, 58].

Total Carbohydrates Contents: From the data presented in Tables 5 it can be noticed that the effect of irrigation intervals on the total carbohydrates percentage was similar to their effect on total chlorophylls content, i.e. the recorded mean values showed a steady decreases as the intervals between irrigation was prolonged from 4 to 7, 10 or 13 days. In the first season, prolonging irrigation intervals from 4 to 7 days caused insignificant reductions in the total carbohydrates percentage, whereas prolonging irrigation intervals up to 10 or 13 days resulted in significant reductions in the recorded mean values, in the second season, the reduction in the total carbohydrates percentage was insignificant as a result of prolonging irrigation intervals from 4 to 7 or 10 days, whereas the longest intervals (13 days) resulted in significant reductions in the mean values, compared to the values recorded with irrigation every 4 days with no significant differences between irrigation every 7 or 10 days.

Table 5: Effect of irrigation intervals and irrigation water salinity on total chlorophylls, total carbohydrates as well as N, P and K (% of dry matter) in leaves of *Leucophyllum frutescens* during the 2014/2015 and 2015/2016 seasons

	First season (2014/2015)					Second season (2015/2016)				
	Irrigation intervals (I)					Irrigation intervals (I)				
Salt concentration (S), ppm	4 days	7 days	10 days	13 days	Mean (S)	4 days	7 days	10 days	13 days	Mean (S)
					Total chlorophylls content (SPAD)					
Control	58.42	50.93	46.06	43.32	49.68	52.25	46.48	43.35	40.67	45.69
1000	55.35	46.50	40.51	38.53	45.22	51.06	43.34	42.81	38.64	43.96
2000	53.57	46.68	40.45	36.46	44.29	45.39	43.23	39.63	38.87	41.78
4000	39.86	39.29	38.12	30.70	36.99	42.01	42.31	35.25	37.63	39.30
6000	30.51	34.68	25.57	22.13	28.22	40.10	41.45	38.39	30.39	37.58
8000	29.76	25.03	24.04	21.67	25.12	35.28	31.88	27.81	26.20	30.29
Mean (I)	44.58	40.52	35.79	32.13	----	44.35	41.45	37.87	35.40	----
L.S.D. (0.05)										
I	4.63					3.63				
S	5.67					4.44				
I X S	11.34					8.89				
					Total carbohydrates (% of dry matter)					
Control	19.32	19.16	16.94	13.97	17.35	18.47	17.38	17.01	12.67	16.38
1000	18.26	16.25	15.06	13.51	15.77	17.92	12.42	12.75	12.29	13.84
2000	17.55	15.33	14.66	13.33	15.22	17.49	12.24	12.40	10.06	13.05
4000	13.32	12.01	11.99	10.57	11.97	12.67	12.15	12.25	8.15	11.31
6000	12.20	12.15	11.58	10.50	11.61	11.95	11.73	11.02	7.77	10.62
8000	11.31	11.03	11.12	8.94	10.60	11.04	10.82	10.47	7.52	9.96
Mean (I)	15.33	14.32	13.56	11.80	----	14.92	12.79	12.65	9.74	----
L.S.D. (0.05)										
I	1.23					2.32				
S	1.51					2.84				
I X S	3.02					5.68				
					N (% dry matter)					
Control	1.91	1.91	1.71	1.71	1.81	1.87	1.80	1.79	1.58	1.76
1000	1.88	1.75	1.70	1.70	1.76	1.84	1.83	1.69	1.43	1.70
2000	1.85	1.85	1.66	1.60	1.74	1.84	1.80	1.61	1.41	1.66
4000	1.51	1.42	1.38	1.38	1.42	1.65	1.48	1.33	1.29	1.44
6000	1.50	1.41	1.27	1.36	1.38	1.54	1.45	1.41	1.25	1.41
8000	1.36	1.26	1.24	0.99	1.21	1.38	1.24	1.23	1.18	1.26
Mean (I)	1.67	1.60	1.49	1.46	----	1.68	1.60	1.51	1.36	----
L.S.D. (0.05)										
I	0.19					0.20				
S	0.23					0.24				
I X S	0.46					0.47				
					P (% dry matter)					
Control	0.27	0.25	0.24	0.21	0.24	0.25	0.25	0.22	0.18	0.22
1000	0.23	0.22	0.22	0.21	0.22	0.22	0.22	0.21	0.18	0.21
2000	0.23	0.22	0.21	0.19	0.21	0.22	0.20	0.18	0.16	0.19
4000	0.18	0.17	0.17	0.16	0.17	0.19	0.17	0.14	0.13	0.16
6000	0.18	0.17	0.15	0.16	0.16	0.17	0.16	0.16	0.13	0.16
8000	0.16	0.15	0.14	0.12	0.14	0.15	0.13	0.14	0.13	0.14
Mean (I)	0.21	0.20	0.19	0.17	----	0.20	0.19	0.17	0.15	----
L.S.D. (0.05)										
I	0.02					0.02				
S	0.03					0.02				
I X S	0.05					0.04				
					K (% dry matter)					
Control	1.94	1.88	1.71	1.44	1.74	2.01	1.95	1.74	1.50	1.80
1000	1.76	1.54	1.55	1.51	1.59	1.81	1.70	1.67	1.42	1.65
2000	1.59	1.53	1.51	1.52	1.54	1.97	1.63	1.50	1.43	1.63
4000	1.55	1.53	1.46	1.55	1.52	1.62	1.56	1.51	1.40	1.52
6000	1.52	1.51	1.36	1.44	1.46	1.53	1.48	1.34	1.31	1.42
8000	1.40	1.32	1.22	1.03	1.24	1.27	1.24	1.20	1.19	1.22
Mean (I)	1.63	1.55	1.47	1.41	----	1.70	1.59	1.49	1.37	----
L.S.D. (0.05)										
I	0.16					0.13				
S	0.19					0.16				
I X S	0.39					0.31				

The reductions in total carbohydrates percentage due to water deficient stress are in agreement with the findings of other researchers [39, 43, 60].

Regarding the effect of salt concentrations the data in Table 5 show that, in most cases, increasing the salt concentration in irrigation water from 1000, 2000, 4000, 6000 to 8000 ppm significantly decreased total carbohydrates percentage compared to the control. The only one exception to this general trend was detected in the second season with plants irrigated with the lowest salt concentration (1000 ppm) which had insignificantly lower values than those recorded with the control. Similar reductions in total carbohydrates percentage as a result of increasing salt stress are consistent with those reported by other studies [53- 54, 61].

The adverse effect of both water deficient and salt stresses on decreasing total chlorophylls contents may be due to the increase in production of reactive oxygen species under both stresses [9], which leads to oxidative stress and damage to chloroplasts structure and chlorophyll loses along with toxic effects of ions. Decreasing chlorophylls contents and photosynthetic activity in stressed plants could indirectly lead to a reduction in carbohydrates percentage. Additionally, soil water deficiency and salt stress conditions helps the abscisic acid translocation from root to shoot of stressed plants through xylem vessels for stomatal closure [62-63], this may be lead to decrease net photosynthesis and carbohydrate accumulation.

Concerning the interaction effects between irrigation intervals and salt concentrations treatments, the data recorded in Table 5 reveal that, in most cases, within each concentration of water salinity treatment, extended irrigation intervals caused steady reduction in total carbohydrates percentage compared to the values recorded with irrigation every 4 day. Within each irrigation intervals treatment, in most cases, raising the salt concentration in irrigation water caused steady reduction in total carbohydrates percentage compared to irrigation with tap water. From the data in Table (5) it can also observed that plants irrigated every 7 or 10 days using tap water or plants irrigated every 4 days using saline water at concentrations of 1000 or 2000 ppm hade total carbohydrates percentage in their leaves which were insignificantly lower than those recorded with that plants irrigated every 4 days using tap water (unstressed control plants).

N, P and K (% of Dry Matter): The results obtained in Table 5 indicate that the different levels of irrigation intervals had a considerable effect on the uptake and accumulation of N, P and K% in the dried leaves of *Leucophyllum frutescens* plants. In both seasons, percentage of the three nutrients was decreased steadily with prolonged irrigation intervals from 4 to 7, 10 or 13 days. Accordingly, the lowest percentage values were obtained from plants irrigated every 13 days, whereas the highest percentage values were obtained from plants irrigated every 4 days. In both seasons, the reduction in the values of N % was insignificant with prolonged irrigation intervals from 4 to 7 or 10, whereas the longest intervals (13 days) significantly reduced N % in dried leaves, compared to the values recorded with irrigation every 4 days, with no significant difference detected between irrigation every 7 or 10 and 13 days in most cases. The reduction in the values of P and K % was insignificant as a result of prolonging irrigation intervals from 4 to 7 days, whereas this reduction was significant with prolonging irrigation intervals up to 10 or 13 days compared to irrigation every 4 days. Similar decreases in percentage of the three nutrients as a result of water deficient stress have been obtained by prior researches [42, 47, 64].

As for the effect of salt concentrations in irrigation water the data in Table 5 show that N, P and K% in the dried leaves were reduced as a result of raising the salt concentration in irrigation water from 1000 to 8000 ppm compared to the control. In both seasons, using saline water at the lower concentrations (1000- 2000 ppm) insignificantly reduced N%, whereas the higher salt concentrations (4000 - 8000 ppm) resulted in significant reduction in the recorded mean values compared to the control. The reduction in P and K % was insignificant in the plants irrigated with the lowest salt concentration (1000 ppm), while increasing salt concentration from 2000 to 8000 ppm caused significant reduction in the recorded mean values compared to the control. Similar reductions in N, P or K% as a result of salt stress have been reported by other researches [53- 56, 65].

The negative effect of water deficient and salinity stress on the uptake and accumulation of the three nutrients in plant leaves may be due to their effect on soil osmotic stress. Water deficient and salinity stress reduce soil moisture content and soil water potential which reduce the elements solubility in the soil and their absorbing efficiency by root surface which in turn leading to reduce their accumulation in plant tissues [66]. In addition to water deficient stress reduces nutrient uptake by the roots and accumulation in the shoots due to limited transpiration rates and impaired active transport and membrane permeability, salt stress cause nutritional imbalance, Na^+ and Cl^- affect the uptake of nutrients by

competing with them or affecting the ion permeability of membrane. Na^+ inhibits K^+ uptake by competing Na^+ with K^+ ions and $NO3^-$ uptake reduced due to the competition with Cl^- [8, 67].

Regarding the interaction effects between irrigation intervals and salt concentrations treatments, the data recorded in Table 5 reveal that the N, P and K% in dried leaves were decreased steadily, in most cases, as a result of prolonging the irrigation intervals and/or raising the salt concentration in irrigation water compared to plants irrigated every 4 days using tap water (unstressed control plants), which gave the highest mean values, whereas the lowest values were obtained from plants irrigated every 13 days using the highest salt concentration (8000 ppm). The data also reveal that the reduction in P and K% was insignificant in leaves of plants irrigated every 7 or 10 days using tap water or in plants irrigated every 4 days using saline water at concentrations of 1000 or 2000 ppm compared to unstressed control plants. In most cases, the reduction in N% was insignificant in leaves of plants irrigated every 7, 10 or 13 days using tap water or using saline water at the concentrations of 1000 or 2000 ppm as well as this reduction in N% was also insignificant in leaves of plants irrigated every 4 days using saline water at concentration up to 6000 ppm compared to the control. The obtained results of reduced N, P or K% as a result of combining water deficient with salt stress are in agreement with findings of previous studies [18].

Na, Cl and Ca (% of Dry Matter): The data in Table 6 show that Na and Cl% in the dried leaves of *Leucophyllum frutescens* plants were increased with prolonging irrigation intervals. In both seasons, prolonging irrigation intervals from 4 to 7 or 10 resulted in slight (insignificant) increases in Na and Cl%, whereas the longest intervals (13 days) caused significant increase in the recorded mean values, compared to irrigation every 4 days, with no significant differences between irrigation every 7 or 10 days. Similar increases in Na% as a result of water stress due to prolonging irrigation intervals have been reported by other researches [39, 42, 43]. However, accumulation of Ca % in dried leaves showed different trend in response to extending irrigation intervals. In both seasons, Ca% was significantly increased and reached its maximum value with prolonging irrigation intervals from 4 to 7 days, flowed by significant decrease with prolonging irrigation intervals to 10 or 13 days compared to irrigation every 4 days, without any significant difference between irrigation every 10 or 13 days compared to each other.

Regarding the effect of salt concentrations in irrigation water the data in Table 6 point out that Na, Cl and Ca% were increased in parallel with raising salt concentration in irrigation water compared to control. In both seasons, the increments in the recorded mean values was insignificant with the lowest salt concentration (1000 ppm), while increasing salt concentration from 2000 to 8000 ppm significantly increased the three mineral elements compared to control. Increases in the accumulation of Na, Cl or Ca% under salinity stress have been demonstrated in various studies [31, 36, 51, 53, 54, 65, 68].

Concerning the interaction effects between irrigation intervals and salt concentrations treatments the data in Table 6 reveal that Na, Cl and Ca% in the dried leaves were generally increased with prolonging the irrigation intervals and/or raising the salt concentration in irrigation water as compared to unstressed control plants (plants irrigated every 4 days using tap water), which gave the lowest values for the three mineral elements in both seasons. On the other hand, the highest values for Na and Cl % were obtained from plants irrigated every 13 days using saline water at concentration of 8000 ppm, while the highest values for Ca % in two seasons were found in plants irrigated every 7 days using saline water at concentration of 8000 ppm. The data in Table 6 also show that plants irrigated every 7 or 10 days using tap or irrigated every 4, 7 or 10 days using saline water at concentration of 1000 or 2000 ppm had insignificantly higher values of Na and Cl toxic ions in their leaves than those recorded with plants irrigated every 4 days using tap water (unstressed control plants). Increases in Na, Cl or Ca concentration in plant organs with increasing water stress and/or salt stress are in agreement with findings of previous researches [16, 18, 19, 58].

Proline Contents: As shown in Table 6, the data indicate that proline content in the fresh leaves of *Leucophyllum frutescens* plants was increased significantly, in most cases, by extending the intervals between irrigations from 4 to 7, 10 or 13 days. The only exception to this general trend was recorded in the second season with plants irrigated every 7 days which hade insignificantly higher values than that obtained from irrigation every 4 days. No significant difference was detected between irrigation every 7, 10 or 13 days compared to each other. Similar increases in proline content as a result of water deficient stress has been reported by many researches [28, 41-43, 47, 69, 70].

Table 6: Effect of irrigation intervals and irrigation water salinity on Na, Cl and Ca (% of dry matter) as well as proline contents in leaves of *Leucophyllum frutescens* during the 2014/2015 and 2015/2016 seasons

	First season (2014/2015)					Second season (2015/2016)				
	Irrigation intervals (I)					Irrigation intervals (I)				
Salt concentration (S), ppm	4 days	7 days	10 days	13 days	Mean (S)	4 days	7 days	10 days	13 days	Mean (S)
					Na (% dry matter)					
Control	0.29	0.32	0.34	0.40	0.34	0.22	0.27	0.32	0.37	0.29
1000	0.32	0.34	0.35	0.45	0.36	0.28	0.32	0.32	0.38	0.33
2000	0.32	0.35	0.40	0.48	0.39	0.32	0.34	0.34	0.47	0.36
4000	0.50	0.52	0.55	0.54	0.53	0.47	0.45	0.47	0.48	0.47
6000	0.66	0.69	0.68	0.69	0.68	0.82	0.86	0.83	0.83	0.84
8000	0.85	0.85	0.82	0.91	0.86	0.92	0.95	0.95	0.99	0.95
Mean (I)	0.49	0.51	0.52	0.58	----	0.50	0.53	0.54	0.58	----
L.S.D. (0.05)										
I	0.04					0.06				
S	0.05					0.07				
I X S	0.10					0.14				
					Cl (% dry matter)					
Control	0.33	0.37	0.37	0.45	0.38	0.26	0.34	0.34	0.41	0.34
1000	0.35	0.35	0.40	0.46	0.39	0.28	0.34	0.35	0.48	0.36
2000	0.37	0.35	0.43	0.59	0.44	0.30	0.34	0.36	0.54	0.39
4000	0.55	0.56	0.51	0.50	0.53	0.50	0.49	0.48	0.54	0.50
6000	0.70	0.71	0.69	0.69	0.70	0.73	0.77	0.76	0.77	0.76
8000	0.75	0.82	0.84	0.84	0.81	0.89	0.78	0.80	0.91	0.84
Mean (I)	0.51	0.53	0.54	0.59	----	0.49	0.51	0.52	0.61	----
L.S.D. (0.05)										
I	0.05					0.04				
S	0.06					0.05				
I X S	0.12					0.11				
					Ca (% dry matter)					
Control	0.39	0.46	0.46	0.48	0.44	0.24	0.32	0.38	0.41	0.34
1000	0.46	0.49	0.50	0.52	0.49	0.31	0.39	0.39	0.38	0.36
2000	0.60	0.66	0.50	0.51	0.56	0.55	0.54	0.42	0.41	0.48
4000	0.76	0.86	0.70	0.71	0.76	0.89	0.93	0.70	0.69	0.81
6000	0.97	1.02	0.77	0.79	0.89	0.87	0.96	0.70	0.68	0.80
8000	1.01	1.06	0.79	0.81	0.92	0.97	1.11	0.80	0.70	0.90
Mean (I)	0.70	0.76	0.62	0.63	----	0.64	0.71	0.56	0.54	----
L.S.D. (0.05)										
I	0.06					0.07				
S	0.07					0.09				
I X S	0.14					0.17				
					Proline content (µ moles/g fresh matter)					
Control	2.53	3.53	3.65	3.83	3.38	2.51	3.73	4.24	4.71	3.80
1000	2.85	4.20	4.25	4.43	3.93	2.82	3.95	4.38	4.64	3.94
2000	4.15	3.95	4.28	4.45	4.21	4.74	4.09	5.13	5.14	4.77
4000	5.85	6.40	6.18	6.33	6.19	5.73	6.70	6.18	7.38	6.50
6000	8.79	10.79	10.29	11.16	10.25	7.30	9.58	10.58	10.11	9.39
8000	11.26	11.49	11.91	13.21	11.97	9.64	9.81	10.82	11.26	10.38
Mean (I)	5.90	6.72	6.76	7.23	----	5.45	6.31	6.89	7.21	----
L.S.D. (0.05)										
I	0.79					1.08				
S	0.97					1.33				
I X S	1.93					2.65				

Proline content as affected by irrigation water salinity, the data in Table 6 show that proline content was increased in response to increasing salt concentration in irrigation water compared to the control plants. In both seasons, the proline content was increased insignificantly as a result of irrigation with saline water at the lower concentrations (1000 to 2000 ppm), whereas using the higher salt concentrations (4000 - 8000 ppm) caused significant increases in the recorded mean values compared to the control. The results of increases of proline content due to salt stress are in agreement with the findings of previous studies [51, 53- 55, 71].

Increases in proline contents in plants as a response to water deficient and salt stress may be because its accumulation is one of the defense mechanisms played by plants to overcome the adverse effects of osmotic and ionic stresses thereby enhance stress tolerance. In addition to the proline function as an excellent osmolyte for intracellular osmotic adjustments to maintaining cell turgor and osmotic balance, it plays an antioxidative defense molecule, free radical scavenger and stabilizes membranes and subcellular structure by preventing electrolyte leakage [10, 72, 73].

Regarding the effect of different combinations of irrigation intervals and irrigation water salinity treatments, the data in Table 6 clear that, in most cases, within each concentration of water salinity treatment prolonging the irrigation intervals resulted in steady increase in proline content, compared to irrigation every 4 day. Within each irrigation intervals treatment, increasing salt concentration in irrigation water resulted in steady increase in proline content compared to irrigation without any salt concentrations (using tap water). Accordingly, the highest values of proline content (13.21 and 11.26 µmoles/g fresh matter in the first and second seasons, respectively) were obtained from plants irrigated every 13 days using saline water at the higher concentration (8000 ppm). On the other hand, the lowest values (2.53 and 2.51 µmoles/g fresh matter in the two seasons, respectively) were obtained from plants irrigated every 4 days using tap water (unstressed control plants). The data in Table 6 indicate that plants irrigated with any of the tested irrigation intervals using saline water at concentrations of 1000 or 2000 ppm or irrigated every 7, 10 or 13 days with using tap water had insignificantly higher proline content in their leaves than those recorded with the unstressed control plants. Similar increases in proline content as a result of combining water deficient stress with salt stress have been reported by other researches [15, 17, 58].

CONCLUSION

Based on the obtained results it can be concluded that, *Leucophyllum frutescens* can be irrigated every 10 days using tap water, or every 4 days using saline water with concentrations up to 2000 ppm, without any significant reduction in most of vegetative growth and flowering parameters.

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