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EFFECTS OF SALINITY ON *APTENIA CORDIFOLIA* AND *WEDELIA TRILOBATA* PLANTS.

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ABSTRACT

The experiments were conducted during two seasons of 2004/2005 and 2005 /2006 at the Floriculture and Ornamental Horticulture Research Garden, at El-Shatby to study the effect of salinity on the growth of *Aptenia cordifolia* and *Wedelia trilobata*. The cuttings of each plant were transplanted in 30 cm. pots containing either sand soil or a mixture of 1clay :1 sand (by volume). The pots were irrigated with tap water for one month then with different levels of (2NaCl: 1$CaCl_2$) at 0, 2, 4, 6 and 8 g/L for six months. Data on plant growth parameters were collected including plant diameter, number of branches, leaf area, dry weights of the shoots and roots. N, P, K, Na, Cl, proline contents in the leaves. All salt concentrations caused significant decreases in plant diameter, shoots and roots dry weights as compared to the control in *Aptenia cordifolia* and *Wedelia trilobata* in both soil types for the two seasons. The number of branches, the leaf area and the leaves chlorophyll content were not significantly affected by salinity in both seasons. There were reductions in N %, P % and K % contents in the leaves of *Aptenia cordifolia* and *Wedelia trilobata* with increasing the salinity level especially in sand soil for both seasons. Generally, the highest Na % in the leaves of *Aptenia cordifolia* and *Wedelia trilobata* was recorded at the highest concentration of salt in clay soil followed by the highest concentration of salt in sand soil in both seasons. Cl % increased gradually with increasing salt concentrations but the differences were not significant. Salt treatments significantly increased the proline content in the leaves of *Aptenia cordifolia* and *Wedelia trilobata* in both soil

types for the two seasons. The highest proline content was recorded in the leaves of *Aptenia cordifolia* in sand soil at the highest salt concentration.

INTRODUCTION

Aptenia cordifolia (Baby Sunrose) family Iozoaceae is a ground cover plant with 2.5 cm long dark green foliage and bright red, aster-like flowers. More often grown in a hanging basket in well drained media, its small stature and slow growth make it suited for a ground cover in a small landscape or rock garden.

Wedelia trilobata L.(Rabbits Paw) family Asteraceae is a low-growing plant with deeply lobed leaves and with 2.5 cm yellow-orange flowers resembling marigolds which are born singly on the end of each stem. Plant creeps and roots at nodes, making a dense ground cover.

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount of water actually in the root zone. Salinity can affect plants in three ways. Initially, salt makes it more difficult for plants to withdraw water from the soil, even if the soil appears quite moist. In effect, the plant suffers from a form of drought which can result in retarded growth and reduced yield. Secondly, some salts, such as Na and Cl can be directly toxic to plants. Plants take up salts with the water that they use, and often these salts can damage the plant internally, affecting the plant's physiological processes and often resulting in reduced growth, leaf burn and even plant death. This effect is the most serious for plants. Thirdly, high amounts of ions such as Na and Cl may affect the availability of other ions e.g. K, Mg, N or P which are extremely important for plant growth (Flowers *et al.*1977)

Soil salinity can affect plant growth both physically (osmotic effect) and chemically (nutritional effect and/or toxicity). Depression of the external osmotic potential by high salt concentrations tends to narrow the gap between the external and internal water potentials. At high salinities, the external osmotic potential may be depressed below that of the plant cell water potential, resulting in osmotic desiccation. The reduction in the osmotic potential of the growth medium has long been held to be the primary cause, directly and indirectly, of the adverse effects of salinity on plant growth and survival. The high concentrations of specific ions can cause disorders in mineral nutrition. For example, high sodium concentrations may cause deficiencies of other elements, such as potassium and calcium, and high levels of sulfate and chloride diminishes the rate of nitrate absorption. Specific ions such as sodium and chloride may have toxic effects on plants; reducing growth or causing damage to cells and membranes. The nutritional deficiencies and toxicities of plants can be characterized by necrosis (tip burning or marginal scorch), chlorosis (turning yellow in color), and abscission (premature dropping).

Generally, a reduction in plant growth - evident by a reduction in plant height or in the number of leaves or shoots - is the plant's first response to salinity. As the plant becomes more affected, it may appear wilted, despite a moist soil, and the leaves may show leaf burn. Under these more severe circumstances, the plant may die. Shoots are generally more inhibited in growth than roots and at low salinity levels root growth may not decrease at all (Greenway and Munns 1980).

Differences exist between plant species in their tolerance of salinity. These differences can be related to the salt content of the soil and/or water which causes an initial decline in growth (yield), and also to the rate of yield decline that occurs with increasing salinity.

The effect of NaCl on plants was associated with higher tissue concentrations of Na, Ca, Cl, P and K (Kandeel and El-quebeti, 1999) . Free proline accumulation in plants was found with salt stress osmo regulation of solutes in many plants (Morgan, 1990).

The aim of the present study is to investigate the salinity effect on the growth of *Aptenia cordifolia* and and *Wedelia trilobata* and to determine the mineral contents in the leaves of these two plants.

MATERIALS AND METHODS

The cuttings of the two floricultural plants (*Aptenia cordifolia* and *Wedelia trilobata*) were obtained from the Floriculture and Ornamental Horticulture Research Garden, at El-Shatbhy.

The study was initiated in 2004/2005 and 2005/2006 in the Floriculture and Ornamental Horticulture Research Garden, at El-

Shatby, to determine the effect of salinity on the growth and mineral contents in the leaves of these two plants.

Sub-terminal cuttings (10 cm) of *Aptenia cordifolia* and *Wedelia trilobata* were planted on September 15, 2004 and September 18, 2005 for the first and second seasons respectively. The rooted cuttings were transplanted to 30 cm clay pots filled with sand soil or1 sand: 1 clay soil (by volume). The soil analysis is presented in Table 1. The pots were irrigated with tap water for four weeks after transplanting. The plants were then subjected to five levels of salinity by irrigating the pots with salt solutions of a mixture of 2NaCl and $1CaCl_2$ by dissolving: 0, 2, 4, 6 and 8 grams per liter. The plants were irrigated every other day using 1 liter of solution per pot. Salt treatments were maintained for 6 months. Every month a washing treatment using tap water was applied to avoid salt accumulation in the root zone. At the end of the experiment on May 25, 2005 and June 4, 2006, ten plants from each treatment were randomly sub sampled measured for plant diameter. Shoots and roots were removed and weighed separately from the stems. Samples were oven-dried . at 70°C for dry weight determination and mineral analysis. Nitrogen was determined calorimetrically according to Evenhuis (1976), P and K were determined according to Evenhuis and Deward (1980), sodium was determined according to Chapman and Pratt (1961), chloride was determined according to Gilliam (1971). Leaves chlorophyll content (mg/g dry weight of leaves) was determined according to Wellburn (1994) and proline (mg/g dry weight of leaves) was determined according to Bates *et al.* (1973). The experiments were carried out in the form of factorial in completely randomized block design with three replications (Steel and Torrie, 1980). Factors used were : Salinity concentrations (five levels), type of soil (two levels) and the season (two levels). Twenty -plants of *Aptenia cordifolia* or *Wedelia trilobata* were used for each experimental unit (plot).

Table (1) . Chemical analysis of the used soil.

Soil	EC dSm^{-1}	pH	Total $CaCO_3$	OM %	soluble anions (meq/ L)			soluble cations (meq/ L)			
					HCO_3	Cl^{-}	SO_4	Ca^{+}	Mg^{+}	Na^{+}	K^{+}
Clay	2.6	8.3	1.7	0.27	0.3	1.7	2.6	1.3	0.9	1.7	0.2
Sand	1.7	7.4	2.5	0.09	0.2	1.8	3.1	0.8	0.4	2.0	0.3

RESULTS AND DISCUSSIONS

Plant diameter

Data presented in Table 2a revealed that all salt concentrations caused a significant decrease in plant diameter as compared to the control in *Aptenia cordifolia* in both soil types for the two seasons. The highest plant diameter recorded at the control treatment in the clay soil, however, the shortest plant resulted from the highest salt concentration in sand soil.

Table (2 a.) Averages of plant diameter of *Aptenia cordifolia* (cm) as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	Season (C)	*Aptenia cordifolia* Plant diameter (cm) Soil Type (B) Clay	Sand	Mean Treatments
0	2004	35.78	32.98	34.38
	2005	36.11	32.77	34.44
mean 0		35.95	32.88	34.41
2	2004	34.08	30.95	32.52
	2005	34.87	31.07	32.97
mean 2		34.48	31.01	32.74
4	2004	31.87	28.85	30.36
	2005	30.99	29.82	30.41
mean 4		31.43	29.34	30.38
6	2004	27.88	25.89	26.89
	2005	26.21	24.58	25.39
mean 6		27.05	25.24	26.14
8	2004	26.31	22.96	24.64
	2005	25.14	21.37	23.26
mean 8		25.73	22.17	23.95
Mean season	2004	31.18	28.33	29.76
	2005	30.66	27.92	29.29
mean type		30.92	28.12	29.52
L.S.D. 0.05 for :				
A- Salinity concentrations		1.27	A x B	0.53
B- Soil type		2.58	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

In *Wedelia trilobata* the plant diameter was affected by salt treatments. By increasing the salt concentrations the plant diameter decreased especially in sand soil in both seasons (Table 2b) .

Table 2 b Averages of plant diameter of *Wedelia trilobata* (cm) as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* Plant diameter (cm) Soil Type (B) Clay	Sand	Mean Treatments
0	2004	46.41	43.76	45.08
	2005	47.87	44.88	46.37
mean 0		47.14	44.32	45.73
2	2004	45.06	43.20	44.13
	2005	44.30	42.08	43.19
mean 2		44.68	42.64	43.66
4	2004	42.39	40.98	41.68
	2005	43.41	39.15	41.28
mean 4		42.90	40.06	41.48
6	2004	39.13	37.25	38.19
	2005	38.23	35.38	36.80
mean 6		38.68	36.31	37.49
8	2004	35.77	32.98	34.37
	2005	34.85	30.06	32.45
mean 8		35.31	31.52	33.41
Mean season	2004	41.75	39.63	40.69
	2005	41.73	38.31	40.02
mean type		41.74	38.97	40.35
L.S.D. 0.05 for :				
A- Salinity concentrations		2.09	A x B	0.81
B- Soil type		1.91	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

These results may be attributed to the toxic effects of Na^+ and Cl^- ions accumulated in the cytoplasm causing reduction in cell division and elongation (Khan *et al*. 2000).

Similar results were reported by Walker and Douglas (1983), Banuls and Primo-Millo (1995) on citrus plants Epron, *et al*.,(1999) on oak and Mohamed (2002) on limber trees.

Number of branches

The number of branches per plant was not significantly affected by either salinity or soil type in both seasons. However, for *Aptenia cordifolia* the lowest value was recorded at 8 g/L salt in sand soil in the second season and at 6 g/L salt in sand soil in the first season (Table 3a).

Table 3 a. Averages of number of branches per plant of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Aptenia cordifolia* Number of branches Soil Type (B) Clay	Sand	Mean Treatments
0	2004	10.71	9.73	10.22
	2005	11.14	8.89	10.02
mean 0		10.93	9.31	10.12
2	2004	6.70	5.63	6.17
	2005	8.12	6.98	7.55
mean 2		7.41	6.31	6.86
4	2004	5.98	4.55	5.27
	2005	4.71	3.90	4.31
mean 4		5.35	4.23	4.79
6	2004	5.81	4.21	5.01
	2005	3.96	4.07	4.02
mean 6		4.89	4.14	4.51
8	2004	4.22	2.29	3.26
	2005	3.07	2.47	2.77
mean 8		3.65	2.38	3.01
Mean season	2004	6.68	5.28	5.98
	2005	6.20	5.26	5.73
mean type		6.44	5.27	5.86
L.S.D. 0.05 for :				
A- Salinity concentrations		2.11	A x B	0.94
B- Soil type		1.84	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

In, *Wedelia trilobata* the treatment of 8 g/L salt caused the maximum decrease in the number of branches in sand soil for both seasons (Table 3b).

Table 3 b. Averages of number of branches per plant of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	**Season (C)**	***Wedelia trilobata***		
		Number of branches		
		Soil Type (B)		**Mean Treatments**
		Clay	**Sand**	
0	2004	12.36	11.09	11.73
	2005	13.15	11.87	12.51
mean 0		12.75	11.48	12.12
2	2004	10.54	9.08	9.81
	2005	10.86	8.74	9.80
mean 2		10.70	8.91	9.81
4	2004	9.87	8.06	8.97
	2005	10.09	7.94	9.02
mean 4		9.98	8.00	8.99
6	2004	8.75	7.91	8.33
	2005	9.33	7.32	8.33
mean 6		9.04	7.62	8.33
8	2004	7.89	7.18	7.54
	2005	8.64	6.44	7.54
mean 8		8.27	6.81	7.54
Mean season	2004	9.88	8.66	9.28
	2005	10.41	8.46	9.44
mean type		10.15	8.56	9.36
L.S.D. 0.05 for :				
A- Salinity concentrations		0.89	A x B	0.79
B- Soil type		2.06	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

These results may be attributed to the presence of chloride ion in high concentrations which might increase its uptake and affect plant growth and branching (Everardo *et al*. 1975). These results are in agreements with those reported by Banuls and Primo-Millo (1995) on citrus plants, Hwang and Yoon (1995) on carnation and El –Kouny *et al.* (2004) on roselle plants.

Leaf area

The results presented in Table 4a show that there were no significant differences in leaf area among salt treatments in *Aptenia cordifolia* in both seasons.

Table 4 a. Averages of leaf area (cm^2) of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	**Season (C)**	***Aptenia cordifolia*** **leaf area (cm^2)**		
		Soil Type (B)		**Mean Treatments**
		Clay	**Sand**	
0	2004	20.01	17.2	18.61
	2005	22.43	18.04	20.24
mean 0		21.22	17.62	19.42
2	2004	17.99	17.09	17.54
	2005	19.07	16.22	17.65
mean 2		18.53	16.66	17.59
4	2004	16.06	15.86	15.96
	2005	16.98	14.62	15.8
mean 4		16.52	15.24	15.88
6	2004	15.83	14.75	15.29
	2005	13.97	12.98	13.48
mean 6		14.90	13.87	14.38
8	2004	15.07	11.23	13.15
	2005	12.84	11.04	11.94
mean 8		13.96	11.135	12.55
Mean season	2004	16.99	15.23	16.11
	2005	17.06	14.58	15.82
mean type		17.06	14.90	15.96
L.S.D. 0.05 for :				
A- Salinity concentrations		N.S.	A x B	N.S.
B- Soil type		1.06	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Similar results were obtained in *Wedelia trilobata* in both seasons (Table 4b).

Table 4 b. Averages of leaf area (cm^2) of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* leaf area (cm^2) Soil Type (B) Clay	Sand	Mean Treatments
0	2004	29.05	24.65	26.85
	2005	27.19	25.36	26.28
mean 0		28.12	25.01	26.56
2	2004	31.16	22.64	26.9
	2005	26.74	22.97	24.86
mean 2		28.95	22.81	25.88
4	2004	27.32	21.75	24.54
	2005	25.99	20.63	23.31
mean 4		26.66	21.19	23.92
6	2004	27.05	20.06	23.56
	2005	26.09	18.86	22.48
mean 6		26.57	19.46	23.02
8	2004	25.77	19.89	22.83
	2005	23.74	17.84	20.79
mean 8		24.76	18.87	21.81
Mean season	2004	28.07	21.79	24.93
	2005	25.95	21.13	23.54
mean type		27.01	21.47	24.24
L.S.D. 0.05 for :				
A- Salinity concentrations		N.S.	A x B	N.S.
B- Soil type		2.09	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

These results may be due to the excess of salts in leaves which modifies the metabolic activities of cell walls causing deposition of various materials which limits the cell wall elasticity. Secondary cell wall become rigid and as a consequence the turgor pressure efficiency in cell wall enlargement decreases. This may cause leaf to remain small (Greenway and Munns. 1980).

Similar findings were obtained by Curtis and Lauchli (1986) on kenaf, Banuls and Primo-Millo (1995) on citrus and Mostafa (2002) on some annual plants.

Leaves chlorophyll content

The leaves chlorophyll content was studied in the second season. The differences among treatments were not significant in both types of soil. In, *Aptenia cordifolia* there was a reduction in leaves chlorophyll content with increasing salt concentrations (Table 5a).

Table 5 a. Averages of Chlorophyll content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2005 season.

Salinity con. (2NaC +1 $CaCl_2$) g/L (A)	***Aptenia cordifolia*** Leaves Chlorophyll content (mg/g D.W.)		
	Soil Type (B)		Mean Treatments
	Clay	Sand	
0	2.33	2.19	2.26
2	2.16	1.87	2.02
4	1.67	1.54	1.61
6	1.37	1.29	1.33
8	1.09	1.01	1.05
mean type	1.72	1.58	1.65
L.S.D. 0.05 for :			
A- Salinity concentration	N.S.		
B- Soil type	N.S.		
A x B	N.S.		

With *Wedelia trilobata* there was a similar reduction trend with increasing salt treatments compared to the control treatment (Table 5b).

Table 5 b. Averages of Chlorophyll content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2005 season.

Salinity con. (2NaC +1 $CaCl_2$) g/L (A)	***Wedelia trilobata*** Leaves Chlorophyll content (mg/g D.W.)		
	Soil Type (B)		**Mean Treatments**
	Clay	**Sand**	
0	3.34	2.98	3.16
2	2.88	2.72	2.80
4	2.45	2.11	2.28
6	2.09	1.98	2.04
8	1.76	1.57	1.67
mean type	2.50	2.27	2.39
L.S.D. 0.05 for :			
A- Salinity concentration	N.S.		
B- Soil type	N.S.		
A x B	N.S.		

These results may be ascribed to three probabilities; toxicity of one or more specific ions, osmotic inhibitions of water absorption and the combination of the two factors (Lapina, 1967).

Similar findings were reported by Banuls and Primo-Millo (1995) on citrus plants, Williams, *et al.*, (1998) on some forest trees, Kennedy and Filippis (1999) on *Grivillea ilicifolia* and Mohamed (2002) on some limber trees.

Shoot Dry weight

The salt treatments led to significantly decrease the dry weight of *Aptenia cordifolia* in both seasons. The reduction was more intense in sand soil (Table 6a).

Table 6 a. Averages of shoot dry weight (g) per plant of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	***Aptenia cordifolia***		
		Shoot dry weight (g)		
		Soil Type (B)		**Mean Treatments**
		Clay	**Sand**	
0	2004	33.41	31.09	32.25
	2005	34.22	32.16	33.19
mean 0		33.81	31.62	32.72
2	2004	32.98	29.87	31.42
	2005	31.99	28.54	30.26
mean 2		32.48	29.20	30.84
4	2004	29.73	26.96	28.34
	2005	29.09	25.00	27.04
mean 4		29.41	25.98	27.69
6	2004	27.53	26.02	26.77
	2005	28.64	24.79	26.71
mean 6		28.08	25.40	26.74
8	2004	26.08	25.75	25.91
	2005	26.98	23.98	25.48
mean 8		26.53	24.86	25.69
Mean season	2004	29.94	27.93	28.94
	2005	30.18	26.89	28.53
mean type		30.06	27.41	28.74
L.S.D. 0.05 for :				
A- Salinity concentrations		1.83	A x B	0.59
B- Soil type		0.76	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Similar results were obtained in *Wedelia trilobata* in both seasons (Table 6b).

These results may be due to the presence of Na^+ ions which reduced the absorption of nutrients leading to the reduction in shoot dry weight (Singh, 2000).

These results are in line with those of Prabucki *et al.* (1999) on *Chrysanthemum morifolium*, Mostafa (2002) on annual plants, Houle and Valery (2003) on *Aster laurentianus* and El –Kouny *et al.* (2004) on roselle plants.

Table 6 b. Averages of shoot dry weight (g) per plant of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ $1CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* Shoot dry weight (g) Soil Type (B) Clay	Sand	Mean Treatments
0	2004	35.77	31.99	33.88
	2005	34.98	29.65	32.32
mean 0		35.38	30.82	33.10
2	2004	32.87	28.94	30.91
	2005	32.01	27.92	29.97
mean 2		32.44	28.43	30.44
4	2004	32.03	25.96	28.99
	2005	29.83	26.99	28.41
mean 4		30.93	26.48	28.70
6	2004	28.95	23.76	26.36
	2005	27.12	22.49	24.81
mean 6		28.04	23.16	25.58
8	2004	27.56	21.97	24.77
	2005	25.94	20.42	23.18
mean 8		26.75	21.19	23.97
Mean season	2004	31.44	26.52	28.98
	2005	29.98	25.49	27.74
mean type		30.71	26.01	28.36
L.S.D. 0.05 for :				
A- Salinity concentrations		1.79	A x B	1.58
B- Soil type		1.86	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Root dry weight

Data presented in Table 7a show that there were significant differences in the root dry weights among salt treatments and between the two soil types in both seasons. In *Aptenia cordifolia* the lowest root dry weight values resulted from 8 g/L salt in sand soil for the first and second seasons, respectively.

Table 7 a. Averages of root dry weight (g) per plant of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	Season (C)	*Aptenia cordifolia* Root dry weight (g) Soil Type (B)		Mean
		Clay	Sand	Treatments
0	2004	10.71	9.73	10.22
	2005	11.14	8.89	10.02
mean 0		10.93	9.31	10.12
2	2004	6.70	5.63	6.17
	2005	8.12	6.98	7.55
mean 2		7.41	6.31	6.86
4	2004	5.98	4.55	5.27
	2005	4.71	3.90	4.31
mean 4		5.35	4.23	4.79
6	2004	5.81	4.21	5.01
	2005	3.96	4.07	4.02
mean 6		4.89	4.14	4.51
8	2004	4.22	2.29	3.26
	2005	3.07	2.47	2.77
mean 8		3.65	2.38	3.01
Mean season	2004	6.68	5.28	5.98
	2005	6.20	5.26	5.73
mean type		6.44	5.27	5.86
L.S.D. 0.05 for :				
A- Salinity concentrations		3.01	A x B	1.43
B- Soil type		2.16	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

The roots of *Wedelia trilobata* were more sensitive and the reduction in root dry weight started at 4 g/L salt in sand soil and at 6g/L salt in clay soil for both seasons. However, the lowest value for root dry weight was recorded at 8 g/L salt in sand soil in the first season (Table 7b).

Table 7 b. Averages of root dry weight (g) per plant of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	Season (C)	*Wedelia trilobata*		
		Root dry weight (g)		
		Soil Type (B)		Mean Treatments
		Clay	Sand	
0	2004	14.64	11.75	13.19
	2005	14.87	12.86	13.87
mean 0		14.76	12.31	13.53
2	2004	11.74	9.72	10.73
	2005	13.08	11.83	12.46
mean 2		12.41	10.78	11.59
4	2004	10.86	8.43	9.65
	2005	11.88	8.09	9.99
mean 4		11.37	8.26	9.82
6	2004	8.98	6.98	7.98
	2005	9.54	5.59	7.56
mean 6		9.26	6.29	7.77
8	2004	6.14	4.75	5.45
	2005	7.22	3.89	5.56
mean 8		6.68	4.32	5.50
Mean season	2004	10.47	8.33	9.39
	2005	11.32	8.45	9.89
mean type		10.89	8.38	9.64
L.S.D. 0.05 for :				
A- Salinity concentrations		2.88	A x B	1.37
B- Soil type		1.06	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

These results may be related to the toxic effect of Na^+ and Cl^- ions which accumulated in the cytoplasm of root cells leading to a reduction in the root cells division and elongation (Khan *et al.*, 2000).

Similar trend of results was found by Wang (1989) Japanese boxwood plants, Banuls and Primo-Millo (1995) on citrus. Katembe, *et al*.,(1998) on Atriplex and Mohamed (2002) on some limber trees.

Leaves nitrogen content

All salt concentrations significantly decreased the nitrogen content in the leaves of *Aptenia cordifolia* in the two soil types in both seasons (Table 8a). The lowest N% was recorded at the highest concentration of salinity in the sand soil.

Table 8 a. Averages of N % content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ $1CaCl_2$) g/L (A)	Season (C)	*Aptenia cordifolia*		
		Leaves N% content		
		Soil Type (B)		Mean
		Clay	Sand	Treatments
0	2004	2.77	2.58	2.68
	2005	2.89	2.63	2.76
mean 0		2.83	2.61	2.72
2	2004	2.63	2.19	2.41
	2005	2.81	2.31	2.56
mean 2		2.72	2.25	2.49
4	2004	2.57	1.99	2.28
	2005	2.60	2.09	2.35
mean 4		2.59	2.04	2.31
6	2004	2.49	1.97	2.23
	2005	2.57	1.94	2.26
mean 6		2.53	1.96	2.24
8	2004	2.29	1.59	1.94
	2005	2.11	1.74	1.93
mean 8		2.20	1.67	1.93
Mean season	2004	2.55	2.06	2.31
	2005	2.59	2.14	2.37
mean type		2.57	2.10	2.34
L.S.D. 0.05 for :				
A- Salinity concentrations		1.61	A x B	0.79
B- Soil type		0.97	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

With *Wedelia trilobata* there was a similar reduction trend with increasing salt treatments compared to the control treatment (Table 8b).

Table 8 b. Averages of N % content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* Leaves N % content		
		Soil Type (B)		Mean Treatments
		Clay	Sand	
0	2004	2.82	2.67	2.76
	2005	3.06	2.74	2.90
mean 0		2.97	2.69	2.83
2	2004	2.68	2.47	2.60
	2005	2.74	2.41	2.58
mean 2		2.71	2.44	2.59
4	2004	2.71	2.43	2.53
	2005	2.62	2.26	2.49
mean 4		2.67	2.35	2.51
6	2004	2.59	1.94	2.27
	2005	2.68	1.87	2.23
mean 6		2.64	1.86	2.25
8	2004	2.43	1.61	2.02
	2005	2.06	1.56	1.81
mean 8		2.66	1.59	1.92
Mean season	2004	2.25	2.22	2.43
	2005	2.63	2.15	2.40
mean type		2.64	2.19	2.41
L.S.D. 0.05 for :				
A- Salinity concentrations		0.13	A x B	1.48
B- Soil type		0.69	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

These results can be attributed to the effect of salinity in reducing the availability of elements needed for root growth (Bertman, 1992).

These results are in agreement with those of El-Khateeb (1993) on *Murraya exotica*, Poljakoff-Mayber, *et a*l., (1994) on *Kosteletzkya virginica*, Kennedy and Filippis (1999) on *Grivillea ilicifolia* and Mostafa (2002) on some annual plants.

Leaves phosphorus content

The results in Table 9a indicate that salt treatments significantly decreased the P % in the leaves as compared with the control. In *Aptenia cordifolia* the lowest P % values resulted from 8 g/L salt in sand soil for the first and second seasons, respectively.

Table 9 a. Averages of P % content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	**Season (C)**	***Aptenia cordifolia***		
		Leaves P% content		
		Soil Type (B)		**Mean Treatments**
		Clay	**Sand**	
0	2004	0.103	0.098	0.101
	2005	0.106	0.102	0.104
mean 0		0.105	0.100	0.102
2	2004	0.092	0.079	0.086
	2005	0.098	0.085	0.092
mean 2		0.095	0.082	0.089
4	2004	0.088	0.073	0.081
	2005	0.085	0.078	0.082
mean 4		0.087	0.076	0.081
6	2004	0.071	0.061	0.066
	2005	0.076	0.058	0.067
mean 6		0.074	0.059	0.067
8	2004	0.060	0.048	0.054
	2005	0.059	0.047	0.053
mean 8		0.059	0.048	0.054
Mean season	2004	0.083	0.072	0.077
	2005	0.085	0.074	0.079
mean type		0.084	0.073	0.078
L.S.D. 0.05 for :				
A- Salinity concentrations		0.84	A x B	1.03
B- Soil type		0.91	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

Similarly, in *Wedelia trilobata* the lowest P % values resulted from 8 g/L salt in sand soil for both seasons (Table 9b).

Table 9 b. Averages of P % content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* Leaves P % content Soil Type (B) Clay	Sand	Mean Treatments
0	2004	0.108	0.105	0.109
	2005	0.110	0.104	0.107
mean 0		0.109	0.105	0.108
2	2004	0.106	0.101	0.104
	2005	0.108	0.103	0.106
mean 2		0.107	0.102	0.105
4	2004	0.094	0.097	0.096
	2005	0.093	0.088	0.091
mean 4		0.094	0.093	0.093
6	2004	0.084	0.072	0.082
	2005	0.087	0.076	0.078
mean 6		0.086	0.074	0.079
8	2004	0.070	0.064	0.067
	2005	0.079	0.062	0.071
mean 8		0.075	0.063	0.069
Mean season	2004	0.092	0.088	0.090
	2005	0.095	0.087	0.091
mean type		0.094	0.087	0.091
L.S.D. 0.05 for :				
A- Salinity concentrations		0.13	A x B	0.96
B- Soil type		0.74	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

Similar results were reported by Francois *et al*. (1986) on durum wheat, Reminson *et al*. (1988) on coconut plants and Makary (1991) on *Chrysanthemum morifolium* .

Leaves potassium content

Leaves potassium content was significantly affected by salt concentrations. There was a reduction in K % with increasing the salinity level especially in sand soil for *Aptenia cordifolia* in both seasons (Table 10a).

Table 10 a. Averages of K % content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ $1CaCl_2$) g/L (A)	Season (C)	*Aptenia cordifolia*		
		Leaves K % content		
		Soil Type (B)		Mean Treatments
		Clay	Sand	
0	2004	1.54	1.24	1.39
	2005	1.51	1.31	1.41
mean 0		1.53	1.28	1.40
2	2004	1.39	1.08	1.24
	2005	1.46	1.18	1.32
mean 2		1.43	1.13	1.28
4	2004	1.28	0.98	1.13
	2005	1.32	1.02	1.17
mean 4		1.30	1.00	1.15
6	2004	1.26	0.72	0.99
	2005	1.17	0.84	1.01
mean 6		1.22	0.78	0.99
8	2004	1.06	0.61	0.84
	2005	1.09	0.63	0.86
mean 8		1.08	0.62	0.85
Mean season	2004	1.30	0.93	1.12
	2005	1.32	0.99	1.15
mean type		1.31	0.96	1.13
L.S.D. 0.05 for :				
A- Salinity concentrations		0.98	A x B	0.08
B- Soil type		0.62	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Similar results were obtained in *Wedelia trilobata* in both seasons (Table 10b).

Table 10 b. Averages of K % content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Wedelia trilobata* Leaves K % content		
		Soil Type (B)		Mean
		Clay	Sand	Treatments
0	2004	1.53	1.23	1.38
	2005	1.58	1.26	1.42
mean 0		1.56	1.25	1.40
2	2004	1.43	1.20	1.32
	2005	1.48	1.19	1.34
mean 2		1.46	1.19	1.33
4	2004	1.41	0.97	1.19
	2005	1.43	1.09	1.26
mean 4		1.42	1.03	1.23
6	2004	1.35	0.91	1.15
	2005	1.38	0.88	1.11
mean 6		1.37	0.89	1.13
8	2004	1.19	0.84	1.02
	2005	1.12	0.78	0.95
mean 8		1.16	0.81	1.22
Mean season	2004	1.38	1.03	0.98
	2005	1.39	1.04	1.21
mean type		1.39	1.04	1.21
L.S.D. 0.05 for :				
A- Salinity concentrations		0.34	A x B	0.20
B- Soil type		0.29	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

These results may be due to Na^+ ions which competes with the uptake of K^+ and reduces its absorption (Darra and Sexana, 1973).

Similar results were found by Reminson *et al*. (1988) on coconut plants, Makary (1991) on *Chrysanthemum morifolium*, Ungar, (1996) on Atriplex and Koryo (2000) on *Beta vulgaris*.

Leaves sodium content

Generally, the highest Na % in the leaves of *Aptenia cordifolia* was recorded at the highest concentration of salt in clay soil followed by the highest concentration of salt in sand soil in both seasons (Table 11a).

Table 11 a. Averages of Na % content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ $1CaCl_2$) g/L (A)	Season (C)	*Aptenia cordifolia* Leaves Na % content Soil Type (B) Clay	Sand	Mean Treatments
0	2004	2.17	2.18	2.18
	2005	2.08	2.03	2.06
mean 0		2.13	2.11	2.12
2	2004	2.23	2.19	2.21
	2005	2.18	2.13	2.16
mean 2		2.21	2.16	2.18
4	2004	2.25	2.29	1.77
	2005	2.26	1.20	2.23
mean 4		2.26	1.75	2.00
6	2004	2.39	2.40	2.39
	2005	2.30	2.39	2.35
mean 6		2.35	2.39	2.37
8	2004	2.49	2.59	2.54
	2005	2.41	2.54	2.48
mean 8		2.45	2.57	2.51
Mean season	2004	2.31	2.13	2.22
	2005	2.25	2.26	2.25
mean type		2.28	2.19	2.24
L.S.D. 0.05 for :				
A- Salinity concentrations		0.38	A x B	0.08
B- Soil type		0.18	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Similarly, in *Wedelia trilobata* the highest Na % values resulted from 8 g/L salt in sand soil for both seasons (Table 11b).

Table 11 b. Averages of Na % content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	Season (C)	*Wedelia trilobata* Leaves Na % content Soil Type (B) Clay	Sand	Mean Treatments
0	2004	2.14	2.17	2.16
	2005	2.09	2.02	2.06
mean 0		2.12	2.09	2.11
2	2004	2.28	2.37	2.33
	2005	2.24	2.31	2.28
mean 2		2.26	2.34	2.30
4	2004	2.32	2.43	2.38
	2005	2.31	2.36	2.34
mean 4		2.32	2.39	2.36
6	2004	2.49	2.54	2.52
	2005	2.48	2.58	2.53
mean 6		2.49	2.56	2.52
8	2004	2.53	2.61	2.57
	2005	2.56	2.59	2.58
mean 8		2.55	2.60	2.57
Mean season	2004	2.35	2.42	2.39
	2005	2.34	2.37	2.35
mean type		2.34	2.39	2.37
L.S.D. 0.05 for :				
A- Salinity concentrations		0.34	A x B	0.20
B- Soil type		0.29	A x C	N.S.
C- season		N.S.	B x C A x B x C	N.S. N.S.

These results may be related to the effect of Na^+ ions which accumulated in the cytoplasm of root cells leading to an accumulation in leaves tissues (Blumwald *et al.* 2000).

These results are in agreement with those of Munoz *et al.* (1997) on *Prosopis alba*, Koryo (2000) on *Beta vulgaris* and Mostafa (2002) on some annual plants.

Leaves chloride content

Data presented in Table 12a revealed that the Cl % was gradually increased with increasing salt concentrations but the differences were not significant. Leaves chloride content in *Aptenia cordifolia* was significantly lower in the control than that of all other treatments in the two soil types for both seasons.

Table 12 a. Averages of Cl % content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	Season (C)	*Aptenia cordifolia* Leaves Cl % content Soil Type (B) Clay	Sand	Mean Treatments
0	2004	0.23	0.24	0.26
	2005	0.26	0.22	0.22
mean 0		0.25	0.23	0.24
2	2004	0.32	0.29	0.31
	2005	0.29	0.25	0.27
mean 2		0.31	0.27	0.29
4	2004	0.39	0.39	0.39
	2005	0.38	0.37	0.38
mean 4		0.39	0.38	0.38
6	2004	0.47	0.49	0.48
	2005	0.47	0.51	0.49
mean 6		0.47	0.50	0.48
8	2004	0.61	0.58	0.59
	2005	0.59	0.57	0.58
mean 8		0.60	0.58	0.59
Mean season	2004	0.40	0.39	0.40
	2005	0.39	0.38	0.39
mean type		0.39	0.39	0.39
L.S.D. 0.05 for :				
A- Salinity concentrations		N.S.	A x B	N.S.
B- Soil type		N.S.	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

Similar results were obtained in *Wedelia trilobata* in both seasons (Table 12b).

Table 12 b. Averages of Cl % content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2004 and 2005 seasons

Salinity conc. (2NaCl+ 1CaCl$_2$) g/L (A)	**Season (C)**	***Wedelia trilobata***		
		Leaves Cl % content		
		Soil Type (B)		**Mean Treatments**
		Clay	**Sand**	
0	2004	0.28	0.25	0.27
	2005	0.21	0.24	0.23
mean 0		0.25	0.25	0.25
2	2004	0.32	0.31	0.32
	2005	0.28	0.30	0.29
mean 2		0.30	0.31	0.30
4	2004	0.34	0.37	0.38
	2005	0.33	0.38	0.34
mean 4		0.34	0.38	0.36
6	2004	0.44	0.49	0.47
	2005	0.41	0.47	0.44
mean 6		0.43	0.48	0.45
8	2004	0.47	0.54	0.50
	2005	0.49	0.52	0.51
mean 8		0.48	0.53	0.51
Mean season	2004	0.37	0.39	0.38
	2005	0.34	0.38	0.36
mean type		0.36	0.39	0.37
L.S.D. 0.05 for :				
A- Salinity concentrations		N.S.	A x B	N.S.
B- Soil type		N.S.	A x C	N.S.
C- season		N.S.	B x C	N.S.
			A x B x C	N.S.

These results may be related to the effect of Cl^- ions which accumulated in the cytoplasm of root cells leading to an accumulation in leaves tissues (Blumwald *et al.* 2000).

Similar results were reported by Francois *et al*. (1986), Munoz *et al.* (1997) on *Prosopis alba,* Wang*, et al.*, (1997) on Atriplex and Mostafa (2002) on some annual plants.

Proline content

Data in Table 13a show that salt treatments significantly increased the proline content in the leaves of *Aptenia cordifolia* in both soil types for the two seasons. The highest proline content was recorded in sand soil at the highest salt concentration.

Table 13 a. Averages of proline content in the leaves of *Aptenia cordifolia* as affected by salinity concentrations and soil type during 2005 season.

Salinity con. (2NaC +1 $CaCl_2$) g/L (A)	*Aptenia cordifolia*		
	Proline content (mg/ g D. W. Leaves)		
	Soil Type (B)		Mean Treatments
	Clay	Sand	
0	6.98	7.44	7.21
2	7.04	8.98	8.01
4	7.88	9.08	8.48
6	8.65	9.93	9.29
8	10.07	11.79	10.93
mean type	8.12	9.44	8.78
L.S.D. 0.05 for :			
A- Salinity concentration	2.11		
B- Soil type	N.S.		
A x B	N.S.		

Similarly, in *Wedelia trilobata* the highest proline content resulted from 8 g/L salt in sand soil (Table 13b).

Table 13 b. Averages of proline content in the leaves of *Wedelia trilobata* as affected by salinity concentrations and soil type during 2005 season.

Salinity con. (2NaC +1 $CaCl_2$) g/L (A)	*Wedelia trilobata*		
	Proline content (mg/ g D. W. Leaves)		
	Soil Type (B)		Mean Treatments
	Clay	Sand	
0	7.87	8.54	8.21
2	8.09	9.01	8.55
4	8.99	9.75	9.37
6	10.13	10.69	10.41
8	10.89	11.08	10.99
mean type	9.19	9.81	9.50
L.S.D. 0.05 for :			
A- Salinity concentration	1.19		
B- Soil type	N.S.		
A x B	N.S.		

These results can be attributed to the role of NaCl in increasing the accumulation of proline in leaves (Yokota, 2003).

These findings are in agreement with those obtained by Unikrishman *et al.* (1991) on *Sapindus trifoliatus*, Banuls and Primo-Millo (1995) on citrus plants, Chuan *et al*. (2002) on rice and Yokota (2003) on Australian Acacia species.

CONCLUSION

According to the salt tolerance categories established by Maas and Hoffman (1977), *Aptenia cordifolia* and *Wedelia trilobata* would be classified as moderately tolerant to salinity. This classification agrees with the seedling tolerance reported by Curtis and Lauchli (1986). Thus, these two plants can be grown successfully with moderately saline irrigation water. However, salt levels in excess of 6 g/L in the irrigation water will restrict plant growth and development. These two ornamental crops, *Aptenia cordifolia* and *Wedelia trilobata* can be grown in a trial experiment using sea water for irrigation.

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الملخص العربي

تأثير الملوحة على نباتى الأبتنيا *Aptenia cordifolia* والويديليا *Wedelia trilobata*

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تم اجراء هذا البحث خلال موسمين متتاليين 2005/2004 و2006/2005 بمزرعة قسم الزهور ونباتات الزينة بالشاطبى **لد**راسة تأثير الملوحة على نباتى الأبتنيا *Aptenia cordifolia* والويديليا *Wedelia trilobata* . تم تفريد النباتات فى أصص تحتوى على تربة رملية أو خليط من الطمى والرمل بنسبة 1:1 وتم رى النباتات لمدة شهر بماء الصنبور ثم بالتركيرات المختلفة من خليط ملحى مكون من 2 كلوريد الصوديوم و 1كلوريد الكالسيوم بتركيزات 0,2,4,6,8 جم/لتر لمدة 6 أشهر. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

أدت زيادة تركيز الملوحة الى نقص معنوى فى نمو النباتين تمثلت فى نقص فى قطرالنباتين كذلك الى نقص فى الوزن الجاف للمجموع الخضرى والجذرى بالمقارنة بنباتات الكنترول فى كل من التربة الرملية و الطميية خلال موسمى البحث. لم يتأثر كل من عدد الأفرع و المساحة الورقية و محتوى الأوراق من الكلوروفيل للنباتات معنويا بزيادة الملوحة وقد سجلت اقل مساحة ورقية فى النباتات المنزرعة فى التربة الرملية عنها فى التربة الطميية . انخفض محتوى الأوراق من كل من النيتروجين والفوسفور والبوتاسيوم معنويا بزيادة تركيز الملوحة فى الموسمين و فى نوعى التربة. سجلت اعلى نسبة مئوية من الصوديوم فى اوراق النباتين تحت الدراسة عند أعلى تركيز من الملوحة فى نباتات التربة الطميية يليها أعلى تركيز ملوحة فى النباتات المنزرعة فى التربة الرملية فى كلا الموسمين. زاد محتوى الأوراق من الكلوريد زيادة تدريجية غير معنوية بزيادة تركيز الملوحة. زاد محتوى الأوراق من البرولين معنويا فى أوراق النباتين و سجلت أعلى قيمة عند أعلى تركيز ملوحة فى التربة الرملية.

مما سبق يتضح أنه يمكن زراعة هذين النباتين بنجاح باستخدام ماء الرى المماثل فى ملوحته للنسب المستعملة فى هذا البحث كما يمكن اجراء بعض الدراسات المستقبلية واستخدام ماء البحر مباشرة للرى بعد التخفيف.