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EFFECTS OF SALINITY ON *Encelia farinosa* AND *Oenothera missouriensis* PLANTS.

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ABSTRACT

The experiments were conducted during two seasons of 2002/2003 and 2003 /2004 at the Floriculture and Ornamental Horticulture Research Garden, at El-Shatby to study the effect of salinity on the growth of two new ornamental plants i.e. *Encelia farinosa* and *Oenothera missouriensis*. The seedlings of each plant were transplanted to 30 cm. pots containing either sandy 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 five months Data on plant growth parameters were collected including plant height(for *Encelia farinosa*) or plant diameter (for *Oenothera missouriensis*) , number of branches, leaf area ,dry weights of the shoots and roots. N, P, K, Na, Cl, chlorophyll and proline contents in the leaves. Results show that salinity significantly decreased general plant growth All salt concentrations caused a significant decrease in plant height or plant diameter, shoots and roots dry weights as compared to the control in *Encelia farinosa* and *Oenothera missouriensis* in both soil types for the two seasons. The number of branches and the leaf area were not significantly affected by salinity in both seasons, however, the type of soil affected the leaf expansion. The lowest expansion of leaves was recorded with sandy soil as compared to clay soil .There were reductions in N %, P % and K % contents in the leaves of *Encelia farinosa* and *Oenothera missouriensis* with increasing the salinity level especially in sandy soil for both seasons. Generally, the highest Na % in the leaves of *Encelia farinosa* and *Oenothera missouriensis* was recorded at the highest concentration of salt in clay soil followed by the highest concentration of salt in sandy soil in both seasons Cl % increased gradually with increasing salt concentrations but the differences were not significant. The leaves chlorophyll content was studied in the second season only, the salt treatments had no effect on chlorophyll content in both types of soil. Salt treatments significantly increased the proline content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* in both soil types for the two seasons. The highest proline content was recorded in the leaves of *Encelia farinosa* in sandy soil at the highest salt concentration. It is concluded that these two plants can be grown successfully with moderately saline irrigation water Further investigation using sea-water for irrigation may confirm that these two potential new ornamental crops, *Encelia farinosa* and *Oenothera missouriensis* can be grown in the North-West Coastal region of Alexandria where irrigation water is a problem.

INTRODUCTION

Encelia farinosa, Brittlebush, Incienso, or Encelia is a showy, desert, shrubby plant growing to 1.5 meter. It's herbage is fragrant, with brittle stems arising from a woody trunk. It produces leaves in a dense cluster, which are a whitish-gray (silvery). It's flower is the bright orange-yellow color typical of a member of the Asteraceae. The plant can be used in borders, as specimen and as low hedges.

Oenothera missouriensis, (bigfruit evening primrose). Family Onagraceae is a herbaceous perennial with trailing habit, 20 -50 cm tall, 30 cm spread with lemon-yellow flowers, 7 to 10 cm in diameter from late spring to mid-summer. Each blossom opens in the evening and lasts only one day, closing in the morning. The plant is used in flowerbeds and in borders (Taylor, 1936).

Salinity stress is a major environmental constraint to irrigated agriculture in the arid and semi-arid regions of the world. Cultural practices, including drainage and irrigation with high quality water, although essential, are expensive. A complementary and more permanent approach to minimizing deleterious effects of soil and water salinity is to select plants that can grow under saline conditions (Epstein *et al.,* 1980).

Salinity is known to retard plant growth through its influence on several facts of plant behavior like osmotic adjustment, ion uptake, protein and nucleic acid synthesis, photosynthesis, enzyme activities and hormonal balance. Plants subjected to saline conditions after the early seeding stage rapidly resumed normal growth rate when the stress was removed but plants subjected to stress during the early seeding stage did not (Dumbroff and Cooper,1974).

Osmotic adjustment under salt stress can occur due to ion uptake from the soil solution or by internal synthesis of organic solutes (Flowers *et al.* 1977). 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 role of proline in osmo regulation has long been questioned. It has been found to be accumulated in plants subject to the severe conditions of both drought and salt stress. Proline in a plant under salt stress could act as both a nitrogen reserve (can be easily converted to glutamate which takes part in the synthesis of other essential amino acids) and in osmo regulation. There is a negative correlation between proline content and salt tolerance (Ashraf, 1994).

The aim of the present study is to investigate the salinity effect on the growth of two new ornamental plants obtained from Al-Bahrain Kingdom i.e. *Encelia farinosa* and *Oenothera missouriensis* to introduce them in the North-West Coastal region of Alexandria where irrigation with high- quality water is a problem.

MATERIALS AND METHODS

The seeds of the two new floricultural plants (*Encelia farinosa* and *Oenothera missouriensis*) were obtained from Al-Bahrain Kingdom.

Preliminary studies to determine the effect of salt stress on seed germination have been conducted using solution cultures in Petri dishes, but these studies provide no information on the effect of salinity beyond the seedling stage of growth. Since salt-tolerance data are not available to predict responses at later stages of growth, a two seasons study was initiated in 2002/2003 and 2003/2004 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 new plants.

Seeds of *Encelia farinosa* and *Oenothera missouriensis* were sown on September 4, 2002 and September 7, 2003 for the first and second seasons respectively. The seedlings were transplanted to 30 cm clay pots filled with sandy 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 volume) by dissolving: 0, 2, 4, 6 and 8 grams per liter. The electric conductivity values were 0.6, 3.8, 7.0, 10.2 and 13.4dS m^{-1}. The plants were irrigated every other day using 1 liter of solution per pot. Salt treatments were maintained for 5 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 March 27, 2003 and April 4, 2004, ten plants from each treatment were randomly sub sampled measured for height for *Encelia farinose* and for plant diameter for *Oenothera missouriensis*. 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 *Encelia farinosa* or *Oenothera missouriensis* 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	2.7	8.5	1.6	0.29	0.3	1.3	2.4	1.4	0 8	1.6	0.2
Sandy	1.8	7.6	2.4	0.07	0.2	16	3 0	0.6	0 3	2.1	0.3

RESULTS AND DISCUSSIONS

Plant height

Data presented in Table 2 revealed that all salt concentrations caused a significant decrease in plant height as compared to the control in *Encelia farinosa* in both soil types for the two seasons. The highest plant height recorded at the control treatment in the clay soil, however, the shortest plant resulted from the highest salt concentration in sandy soil. In *Oenothera* *missouriensis* the plant diameter was affected by salt treatments. By increasing the salt concentrations the plant diameter decreased especially in sandy soil in both seasons.

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 and Mohamed (2002) on limber trees.

Table 2. Averages of plant height of *Encelia farinosa* and plant diameter of *Oenothera missouriensis* (cm) as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl+ 1$CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa* Plant height (cm)			*Oenothera missouriensis* Plant diameter (cm)		
		Soil Type (B)		Mean Treatments	Soil Type (B)		Mean Treatments
		Clay	Sandy		Clay	Sandy	
0	2002	46.41	43.76	45.08	33.41	31.09	32.25
	2003	47.87	44.88	46.37	34.22	32.16	33.19
mean 0		47.14	44.32	45.73	33.81	31.62	32.72
2	2002	45.06	43.20	44.13	32.98	29.87	31.42
	2003	44.30	42.08	43.19	31.99	28.54	30.26
mean 2		44.68	42.64	43.66	32.48	29.20	30.84
4	2002	42.39	40.98	41.68	29.73	26.96	28.34
	2003	43.41	39.15	41.28	29.09	25.00	27.04
mean 4		42.90	40.06	41.48	29.41	25.98	27.69
6	2002	39.13	37.25	38.19	27.53	26.02	26.77
	2003	38.23	35.38	36.80	28.64	24.79	26.71
mean 6		38.68	36.31	37.49	28.08	25.40	26.74
8	2002	35.77	32.98	34.37	26.08	25.75	25.91
	2003	34.85	30.06	32.45	26.98	23.98	25.48
mean 8		35.31	31.52	33.41	26.53	24.86	25.69
Mean season	2002	41.75	39.63	40.69	29.94	27.93	28.94
	2003	41.73	38.31	40.02	30.18	26.89	28.53
mean type		41.74	38.97	40.35	30.06	27.41	28.74
L.S.D. 0.05 for :							
A- Salinity concentrations		1.49			0.97		
B- Soil type		2.01			1.70		
C- season		N.S.			N.S.		
A x B		0.48			0.69		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Number of branches

The number of branches per plant was not significantly affected by either salinity or soil type in both seasons. However, for *Encelia farinosa* the lowest value was recorded at 8 g/L salt in sandy soil in the second season and at 6 g/L salt in sandy soil in the first season. In *Cenothera missouriensis*, the treatment of 8 g/L salt caused the maximum decrease in the number of branches in sandy soil for both seasons (Table 3). 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.

Table 3. Averages of number of branches per plant of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl +1 $CaCl_2$) g/L (A)	Season (C)	*Encelia farinose* Number of branches Soil Type (B) Clay	Sandy	Mean Treatments	*Oenothera missouriensis* Number of branches Soil Type (B) Clay	Sandy	Mean Treatments
0	2002	8.44	7.65	8.05	12.36	11.09	11.73
	2003	7.52	7.98	7.75	13.15	11.87	12.51
mean 0		7.98	7.82	7.89	12.75	11.48	12.12
2	2002	8.62	6.87	7.75	10.54	9.08	9.81
	2003	6.99	7.03	7.01	10.86	8.74	9.80
mean 2		7.80	6.95	7.38	10.70	8.91	9.81
4	2002	6.42	6.84	6.63	9.87	8.06	8.97
	2003	7.08	5.97	6.53	10.09	7.94	9.02
mean 4		6.75	6.41	6.58	9.98	8.00	8.99
6	2002	6.14	4.39	5.27	8.75	7.91	8.33
	2003	5.83	4.98	5.41	9.33	7.32	8.33
mean 6		5.98	4.69	5.34	9.04	7.62	8.33
8	2002	5.11	4.61	4.86	7.89	7.18	7.54
	2003	4.87	4.35	4.61	8.64	6.44	7.54
mean 8		4.99	4.48	4.74	8.27	6.81	7.54
Mean season	2002	6.94	6.07	6.51	9.88	8.66	9.28
	2003	6.45	6.06	6.26	10.41	8.46	9.44
mean type		6.70	6.07	6.38	10.15	8.56	9.36
L.S D. 0.05 for :							
A- Salinity concentrations		N.S.			N.S.		
B- Soil type		N.S.			N.S.		
C- season		N.S.			N.S.		
A x B		N.S			N.S		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Leaf area

The results presented in Table 4 show that there were no significant differences in leaf area among salt treatments in *Encelia farinosa* and *Oenothera missouriensis* in both seasons. Whereas, the type of soil affected the leaf expansion. The lowest expansion of leaves was recorded with sandy soil as compared to clay soil in salt treated and untreated plants in both seasons. 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 (Everardo *et al.* 1975).

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.

Table 4. Averages of leaf area (cm^2) of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. ($2NaCl+1 CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa* Leaf area (cm^2) Soil Type (B) Clay	Sandy	Mean Treatments	*Oenothera missouriensis* Leaf area (cm^2) Soil Type (B) Clay	Sandy	Mean Treatments
0	2002	29.05	24.65	26.85	20.01	17.2	18.61
	2003	27.19	25.36	26.28	22.43	18.04	20.24
mean 0		28.12	25.01	26.56	21.22	17.62	19.42
2	2002	31.16	22.64	26.9	17.99	17.09	17.54
	2003	26.74	22.97	24.86	19.07	16.22	17.65
mean 2		28.95	22.81	25.88	18.53	16.66	17.59
4	2002	27.32	21.75	24.54	16.06	15.86	15.96
	2003	25.99	20.63	23.31	16.98	14.62	15.8
mean 4		26.66	21.19	23.92	16.52	15.24	15.88
6	2002	27.05	20.06	23.56	15.83	14.75	15.29
	2003	26.09	18.86	22.46	13.97	12.98	13.48
mean 6		26.57	19.46	23.02	14.90	13.87	14.38
8	2002	25.77	19.89	22.83	15.07	11.23	13.15
	2003	23.74	17.84	20.79	12.84	11.04	11.94
mean 8		24.76	18.87	21.81	13.96	11.135	12.55
Mean season	2002	28.07	21.79	24.93	16.99	15.23	16.11
	2003	25.95	21.13	23.54	17.06	14.58	15.82
mean type		27.01	21.47	24.24	17.06	14.90	15.96
L.S.D. 0.05 for :							
A- Salinity concentrations		N.S.			N.S.		
B- Soil type		2.17			1.93		
C- season		N.S.			N.S		
A x B		N.S.			N.S.		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Shoot Dry weight

The salt treatments led to significantly decrease the dry weight of *Encelia farinosa* and *Oenothera missouriensis* in both seasons. The reduction was more intense in sandy soil (Table 5).

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 and El –Kouny *et al.* (2004) on roselle plants.

Table 5. Averages of shoot dry weight (g) per plant of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl +1 $CaCl_2$) g/L (A)	Season (C)	*Encelia farinose* Shoot dry weight (g)			*Oenothera missouriensis* Shoot dry weight (g)		
		Soil Type (B)		Mean Treatments	Soil Type (B)		Mean Treatments
		Clay	Sandy		Clay	Sandy	
0	2002	35.78	32.98	34.38	25.77	21.99	23.88
	2003	36.11	32.77	34.44	24.98	19.65	22.32
Mean 0		35.95	32.88	34.41	25.38	20.82	23.09
2	2002	34.08	30.95	32.52	22.87	18.94	20.91
	2003	34.87	31.07	32.97	22.01	17.92	19.97
mean 2		34.48	31.01	32.74	22.44	18.43	20.44
4	2002	31.87	28.85	30.36	22.03	15.96	18.99
	2003	30.99	29.82	30.41	19.83	16.99	18.41
mean 4		31.43	29.34	30.38	20.93	16.48	18.70
6	2002	27.88	25.89	26.89	18.95	13.76	16.36
	2003	26.21	24.58	25.39	17.12	12.49	14.81
mean 6		27.05	25.24	26.14	18.035	13.13	15.58
8	2002	26.31	22.96	24.64	17.56	11.97	14.77
	2003	25.14	21.37	23.26	15.94	10.42	13.18
mean 8		25.73	22.17	23.95	16.75	11.19	13.97
Mean season	2002	31.18	28.33	29.76	21.44	16.52	18.98
	2003	30.66	27.92	29.29	19.98	15.49	17.74
mean type		30.92	28.12	29.52	20.71	16.01	18.36
L.S.D. 0.05 for :							
A- Salinity concentrations		0.48			0.93		
B- Soil type		1.13			2.47		
C- season		N.S.			N.S.		
A x B		2.51			1.78		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Root dry weight

Data presented in Table 6 show that there were significant differences in the root dry weights among salt treatments and between the two soil types in both seasons. In *Encelia farinosa* the lowest root dry weight values resulted from 8 g/L salt in sandy soil for the first and second seasons, respectively. The roots of *Oenothera missouriensis* were more sensitive and the reduction in root dry weight started at 4 g/L salt in sandy 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 sandy soil in the first season.

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 (1992) Japanese boxwood plants, Banuls and Primo-Millo (1995) on citrus and Mohamed (2002) on some limber trees.

Table 6. Averages of root dry weight (g) per plant of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl+1 $CaCl_2$) g/L (A)	Season (C)	*Encelia farinose* Root dry weight (g) Soil Type (B) Clay	Sandy	Mean Treatments	*Oenothera missouriensis* Root dry weight (g) Soil Type (B) Clay	Sandy	Mean Treatments
0	2002	14.64	11.75	13.19	10.71	9.73	10.22
	2003	14.87	12.86	13.87	11.14	8.89	10.02
mean 0		14.76	12.31	13.53	10.93	9.31	10.12
2	2002	11.74	9.72	10.73	6.70	5.63	6.17
	2003	13.08	11.83	12.46	8.12	6.98	7.55
mean 2		12.41	10.78	11.59	7.41	6.31	6.86
4	2002	10.86	8.43	9.65	5.98	4.55	5.27
	2003	11.88	8.09	9.99	4.71	3.90	4.31
mean 4		11.37	8.26	9.82	5.35	4.23	4.79
6	2002	8.98	6.98	7.98	5.81	4.21	5.01
	2003	9.54	5.59	7.56	3.96	4.07	4.02
mean 6		9.26	6.29	7.77	4.89	4.14	4.51
8	2002	6.14	4.75	5.45	4.22	2.29	3.26
	2003	7.22	3.89	5.56	3.07	2.47	2.77
mean 8		6.68	4.32	5.50	3.65	2.38	3.01
Mean season	2002	10.47	8.33	9.39	6.68	5.28	5.98
	2003	11.32	8.45	9.89	6.20	5.26	5.73
mean type		10.89	8.38	9.64	6.44	5.27	5.86
L.S.D. 0.05 for :							
A- Salinity concentrations.		4.16			3.21		
B- Soil type		0.91			1.01		
C- season		N.S.			N.S.		
A x B		0.76			0.94		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Leaves nitrogen content

All salt concentrations significantly decreased the nitrogen content in the leaves of the two plants (*Encelia farinosa* and *Oenothera missouriensis*) in the two soil types in both seasons (Table 7). The lowest N% was recorded at the highest concentration of salinity in the sandy soil. These results can be attributed to the effect of salinity in reducing the availability of elements needed for root growth (Berlman, 1992).

These results are in agreement with those of El-Khateeb (1993) on *Murraya exotica*, Kennedy and Filippis (1999) on *Grivillea ilicifolia* and Mostafa (2002) on some annual plants.

Table 7. Averages of N % content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. ($2NaCl+CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa* Leaves N% content			*Oenothera missouriensis* Leaves N % content		
		Soil Type (B)		Mean Treatments	Soil Type (B)		Mean Treatments
		Clay	Sandy		Clay	Sandy	
0	2002	3.09	2.72	2.91	2.89	2.63	2.76
	2003	2.84	2.67	2.76	2.77	2.58	2.68
mean 0		2.97	2.69	2.83	2.83	2.61	2.72
2	2002	2.74	2.41	2.58	2.81	2.31	2.56
	2003	2.68	2.47	2.58	2.63	2.19	2.41
mean 2		2.71	2.44	2.58	2.72	2.25	2.49
4	2002	2.71	2.26	2.49	2.6	2.09	2.35
	2003	2.62	2.43	2.53	2.57	1.99	2.28
mean 4		2.67	2.35	2.51	2.59	2.04	2.31
6	2002	2.68	1.78	2.23	2.57	1.94	2.26
	2003	2.59	1.94	2.27	2.49	1.97	2.23
mean 6		2.64	1.86	2.25	2.53	1.96	2.24
8	2002	2.06	1.56	1.81	2.11	1.74	1.93
	2003	2.43	1.61	2.02	2.29	1.59	1.94
mean 8		2.25	1.59	1.92	2.20	1.67	1.93
Mean season	2002	2.66	2.15	2.40	2.59	2.14	2.37
	2003	2.63	2.22	2.43	2.55	2.06	2.31
mean type		2.64	2.19	2.41	2.57	2.10	2.34
L.S.D. 0.05 for :							
A- Salinity concentrations		0.13			1.61		
B- Soil type		0.69			0.97		
C- season		N.S.			N.S		
A x B		0.92			1.48		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Leaves phosphorus content

The results in Table 8 indicate that salt treatments significantly decreased the P % in the leaves as compared with the control. In *Encelia farinosa* the lowest P % values resulted from 8 g/L salt in sandy soil for the first and second seasons, respectively. Similarly, in *Oenothera missouriensis* the lowest P % values resulted from 8 g/L salt in sandy soil for both seasons.

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* .

Table 8. Averages of P % content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl +1 $CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa* Leaves P% content Soil Type (B) Clay	Sandy	Mean Treatments	*Oenothera missouriensis* Leaves P% content Soil Type (B) Clay	Sandy	Mean Treatments
0	2002	0.110	0.104	0.107	0.106	0.102	0.104
	2003	0.108	0.105	0.106	0.103	0.098	0.101
Mean 0		0.109	0.105	0.108	0.105	0.100	0.102
2	2002	0.108	0.103	0.106	0.098	0.085	0 092
	2003	0.106	0.101	0.104	0.092	0.079	0.086
mean 2		0.107	0.102	0 105	0.095	0.082	0.089
4	2002	0.093	0.088	0.091	0.085	0.078	0.082
	2003	0.094	0.097	0.096	0.088	0.073	0.081
mean 4		0.094	0.093	0.093	0.087	0.076	0.081
6	2002	0.087	0.076	0.082	0.076	0.058	0.067
	2003	0.084	0.072	0.078	0.071	0.061	0 066
mean 6		0.086	0.074	0.079	0.074	0.059	0.067
8	2002	0.079	0.062	0.071	0.059	0.047	0.053
	2003	0 070	0.064	0.067	0.060	0.048	0.054
mean 8		0.075	0.063	0.069	0.059	0.048	0.054
Mean season	2002	0.095	0.087	0.091	0.085	0.074	0.079
	2003	0.092	0.088	0 090	0.083	0.072	0.077
mean type		0.094	0.087	0.091	0.084	0.073	0.078
L.S.D. 0.05 for :							
A- Salinity concentration		0.13			0.84		
B- Soil type		0.74			0.91		
C- season		N.S.			N.S		
A x B		0.96			1.03		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

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 sandy soil for *Encelia farinosa* and *Oenothera missouriensis* in both seasons (Table 9).

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* and Koryo (2000) on *Beta vulgaris*.

Table 9. Averages of K % content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl + 1CaCl₂) g/L (A)	Season (C)	*Encelia farinosa* Leaves K% content Soil Type (B) Clay	Sandy	Mean Treatments	*Oenothera missouriensis* Leaves K% content Soil Type (B) Clay	Sandy	Mean Treatments
0	2002	1.58	1.26	1.42	1.51	1.31	1.41
	2003	1.53	1.23	1.38	1.54	1.24	1.39
Mean 0		1.56	1.25	1.40	1.53	1.28	1.40
2	2002	1.48	1.19	1.34	1.46	1.18	1.32
	2003	1.43	1.20	1.32	1.39	1.08	1.24
Mean 2		1.46	1.19	1.33	1.43	1.13	1.28
4	2002	1.43	1.09	1.26	1.32	1.02	1.17
	2003	1.41	0.97	1.19	1.28	0.98	1.13
mean 4		1.42	1.03	1.23	1.30	1.00	1.15
6	2002	1.38	0.88	1.13	1.17	0.84	1.01
	2003	1.35	0.91	1.13	1.26	0.72	0.99
mean 6		1.37	0.89	1.13	1.22	0.78	0.99
8	2002	1.12	0.78	0.95	1.09	0.63	0.86
	2003	1.19	0.84	1.02	1.06	0.61	0.84
mean 8		1.16	0.81	0.98	1.08	0.62	0.85
Mean season	2002	1.39	1.04	1.22	1.31	0.99	1.15
	2003	1.38	1.03	1.21	1.31	0.93	1.12
mean type		1.39	1.04	1.21	1.31	0.96	1.13
L.S.D. 0.05 for :							
A-Salinity concentrations		0.34			0.98		
B- Soil type		0.29			0.62		
C- season		N.S.			N.S.		
A x B		0.19			0.09		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Leaves sodium content

Generally, the highest Na % in the leaves of *Encelia farinosa* and *Oenothera missouriensis* was recorded at the highest concentration of salt in clay soil followed by the highest concentration of salt in sandy soil in both seasons (Table 10). 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.

Table 10. Averages of Na % content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. (2NaCl + 1$CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa*			*Oenothera missouriensis*		
		Leaves Na % content			Leaves Na % content		
		Soil Type (B)		Mean Treatments	Soil Type (B)		Mean Treatments
		Clay	Sandy		Clay	Sandy	
0	2002	2.09	2.02	2.06	2.08	2.03	2.06
	2003	2.14	2.17	2.16	2.17	2.18	2.18
Mean 0		2.12	2.09	2.11	2.13	2.11	2.12
2	2002	2.24	2.31	2.28	2.18	2.13	2.16
	2003	2.28	2.37	2.33	2.23	2.19	2.21
mean 2		2.26	2.34	2.30	2.21	2.16	2.18
4	2002	2.31	2.36	2.34	2.26	2.20	2.23
	2003	2.32	2.43	2.38	2.25	1.29	1.77
mean 4		2.32	2.39	2.36	2.26	1.75	2.00
6	2002	2.48	2.58	2.53	2.30	2.39	2.35
	2003	2.49	2.54	2.52	2.39	2.40	2.39
mean 6		2.49	2.56	2.52	2.35	2.39	2.37
8	2002	2.56	2.59	2.58	2.41	2.54	2.48
	2003	2.53	2.61	2.57	2.49	2.59	2.54
mean 8		2.55	2.60	2.57	2.45	2.57	2.51
Mean season	2002	2.34	2.37	2.35	2.25	2.26	2.25
	2003	2.35	2.42	2.39	2.31	2.13	2.22
mean type		2.34	2.39	2.37	2.28	2.19	2.24
L.S.D. 0.05 for:							
A- Salinity concentrations		0.17			0.38		
B- Soil type		0.62			0.18		
C- season		N.S.			N.S.		
A x B		0.93			0.14		
A x C		N.S.			N.S.		
B x C		N.S.			N.S.		
A x B x C		N.S.			N.S.		

Leaves chloride content

Data presented in Table 11 revealed that the Cl % was gradually increased with increasing salt concentrations but the differences were not significant. Leaves chloride content in *Encelia farinosa* and *Oenothera missouriensis* was significantly lower in the control than that of all other treatments in the two soil types for both seasons. 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* and Mostafa (2002) on some annual plants.

Table 11. Averages of Cl % content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2002 and 2003 seasons.

Salinity conc. 2NaCl +1 $CaCl_2$) g/L (A)	Season (C)	*Encelia farinosa* Leaves Cl % content			*Oenothera missouriensis* Leaves Cl % content		
		Soil Type (B)		Mean Treatments	Soil Type (B)		Mean Treatments
		Clay	Sandy		Clay	Sandy	
0	2002	0 21	0.24	0.23	0.26	0.22	0.24
	2003	0.28	0.25	0.27	0.23	0.24	0.24
Mean 0		0.25	0.25	0.25	0.25	0.23	0.24
2	2002	0.28	0.30	0.29	0.29	0.25	0.27
	2003	0.32	0.31	0 32	0.32	0 29	0.31
Mean 2		0.30	0.31	0.30	0.31	0.27	0.29
4	2002	0.33	0.38	0.36	0.38	0.37	0.38
	2003	0.34	0.37	0.36	0.38	0 39	0.39
mean 4		0.34	0.38	0.36	0.38	0 38	0.38
6	2002	0.41	0.47	0 44	0.46	0.51	0.49
	2003	0 44	0.49	0 47	0.47	0.49	0.48
mean 6		0.43	0.48	0.45	0.47	0.5	0.48
8	2002	0.49	0.52	0.51	0.59	0.57	0.58
	2003	0.47	0.54	0.51	0.61	0.58	0.59
mean 8		0 48	0.53	0.51	0.60	0.58	0.59
Mean season	2002	0.34	0.38	0.36	0.39	0 38	0.39
	2003	0.37	0.39	0.38	0.40	0 39	0.40
mean type		0.36	0.39	0.37	0.39	0 39	0.39
L.S D. 0.05 for :							
A- Salinity concentration		N.S.			N.S.		
B- Soil type		N.S			N.S.		
C- season		N.S.			N.S.		
A x B		N S.			N.S.		
A x C		N S.			N.S.		
B x C		N.S			N.S.		
A x B x C		N.S.			N.S.		

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 *Encelia farinosa*, there was a reduction in leaves chlorophyll content with increasing salt concentrations. With *Oenothera missouriensis* there was a similar reduction trend with increasing salt treatments compared to the control treatment (Table 12). 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, Kennedy and Filippis (1999) on *Grivillea ilicifolia* and Mohamed (2002) on some limber trees.

Table 12. Averages of Chlorophyll content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2003 season.

Salinity con. (2NaC +1 $CaCl_2$) g/L (A)	*Encelia farinosa* Leaves Chlorophyll content (mg/g D.W.)			*Oenothera missouriensis* Leavesl Chlorophyll content (mg/g D.W.)		
	Soil Type (B)		Mean	Soil Type (B)		Mean
	Clay	Sandy	Treatments	Clay	Sandy	Treatments
0	2.33	2.19	2.26	3.34	2.98	3.16
2	2.16	1.87	2.02	2.88	2.72	2.80
4	1.67	1.54	1.61	2.45	2.11	2.28
6	1.37	1.29	1.33	2.09	1.98	2.04
8	1.09	1.01	1.05	1.76	1.57	1.67
mean type	1.72	1.58	1.65	2.50	2.27	2.39
L.S D. 0.05 for :						
A- Salinity concentration	N.S.			N.S.		
B- Soil type	N.S.			N.S.		
A x B	N.S.			N.S.		

Proline content

Data in Table 13 show that salt treatments significantly increased the proline content in the leaves of *Encelia farinosa* and *Oenothera missouriersis* in both soil types for the two seasons. The highest proline content was recorded in the leaves of *Encelia farinosa* in sandy soil at the highest salt concentration. 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.

Table 13. Averages of proline content in the leaves of *Encelia farinosa* and *Oenothera missouriensis* as affected by salinity concentrations and soil type during 2003 season.

Salinity conc. (2NaCl+ $CaCl_2$) g/L (A)	*Encelia farinose* Proline content (mg/ g D. W. Leaves)			*Oenothera missouriensis* Proline content (mg/ g D. W. Leaves)		
	Soil Type (B)		Mean	Soil Type (B)		Mean
	Clay	Sandy	Treatments	Clay	Sandy	Treatments
0	7.87	8.54	8.21	6.98	7.44	7.21
2	8.09	9.01	8.55	7.04	8.98	8.01
4	8.99	9.75	9.37	7.88	9.08	8.48
6	10.13	10.69	10.41	8.65	9.93	9.29
8	10.89	11.08	10.99	10.07	11.79	10.93
mean type	9.19	9.81	9.50	8.12	9.44	8.78
L.S.D. 0.05 for :						
A- Salinity concentration	1.17			2.11		
B- Soil type	N.S.			N.S.		
A x B	N.S.			N.S.		

Conclusions

According to the salt tolerance categories established by Maas and Hoffman (1977), *Encelia farinosa* and *Oenothera missouriensis* 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 potential new ornamental crops, *Encelia farinosa* and *Oenothera missouriensis* can be grown as a trial experiment in the North-West Coastal region of Alexandria using sea water for irrigation.

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تأثير الملوحة على نباتي *Encelia farinosa* و *Oenothera missouriensis*

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تم اجراء هذا البحث خلال موسمين متتاليين ٢٠٠٢/٢٠٠٣ و٢٠٠٣/٢٠٠٤ بمزرعة قسم الزهور ونباتات الزينة بالشاطبى لدراسة تأثير الملوحة على نباتي *Encelia farinosa* و *Oenothera missouriensi* . تم تفريد النباتات في أصص تحتوى على تربة رملية أو خليط من الطمى والرمل بنسبة ١:١ وتم رى النباتات لمدة شهر بماء الصنبور ثم بالتركيزات المختلفة من خليط ملحى كلوريد الصوديوم وكلوريد الكالسيوم بنسبة 1:2 بتركيزات ٠،٢،٤،٦،٨ جم/لتر لمدة ٥ أشهر. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

- أدت زيادة تركيز الملوحة الى نقص معنوى في نمو النبات تمثلت في خفض ارتفاع نبات *Encelia farinosa* ونقص في قطر نبات *Oenothera missouriensi* كذلك الى نقص في الوزن الجاف للمجموع الخضرى والجذرى بالمقارنة بنباتات الكنترول في كل من التربة الرملية و الطميية خلال موسمى البحث.
- لم يتأثركل من عدد الأفرع و المساحة الورقية للنباتات معنويا بزيادة الملوحة وقد سجلت اقل مساحة ورقية في النباتات المنزرعة في التربة الرملية عنها في التربة الطميية .
- انخفض محتوى الأوراق من كل من النيتروجين والفوسفور والبوتاسيوم معنويا بزيادة تركيز الملوحة في الموسمين و في نوعى التربة.
- سجلت اعلى نسبة مئوية من الصوديوم في اوراق النباتين تحت الدراسة عند أعلى تركيز من الملوحة في نباتات التربة الطميية يليها أعلى تركيز ملوحة في النباتات المنزرعة في التربة الرملية في كلا الموسمين.
- زاد محتوى الأوراق من الكلوريد زيادة تدريجية غير معنوية بزيادة تركيز الملوحة.
- لم تؤثر تركيزات الملوحة معنويا على محتوى الأوراق من الكلوروفيل بينما زاد محتواها من البرولين معنويا في أوراق النباتين و سجلت أعلى قيمة عند أعلى تركيز ملوحة في التربة الرملية.
- مما سبق يتضح أنه يمكن زراعة هذين النباتين بنجاح باستخدام ماء الرى المماثل في ملوحته للنسب المستعملة في هذا البحث كما يمكن اجراء بعض الدراسات المستقبلية واستخدام ماء البحر مباشرة للرى قبل التوصية بزراعة هذين النباتين في الساحل الشمالى الغربى للأسكندرية حيث يعتبر توفر ماء الرى مشكلة اساسية في هذه المنطقة.