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TOLERANCE OF *Cryptostegia grandiflora*, R. Br. GROWN IN SANDY SOIL TO IRRIGATION WATER SALINITY

BY

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ABSTRACT

This study was conducted at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2006/2007 and 2007/2008. The aim of this study was to investigate the tolerance of *Cryptostegia grandiflora* plants grown in sandy soil to irrigation water salinity. The plants were irrigated (till 100% of field capacity) every week using tap water (control, 270 ppm) or water containing a mixture of NaCl and $CaCl_2$ (1:1 w/w) at concentrations of 3000, 6000, 9000 or 12000 ppm.

Raising salt concentrations in irrigation water up to 9000 ppm insignificantly reduced the survival percentage, vine length and fresh weights of leaves and roots, while using salt concentrations up to 6000 ppm insignificantly reduced stem diameter, number of branches, dry weight of leaves and fresh and dry weights of stems as well as total chlorophylls content, compared to the control. Also, raising the salt concentrations increased the total carbohydrates, Na, Ca and Cl and proline contents as compared to the control.

From the above results, it can be concluded that *Cryptostegia grandiflora* plants grown in sandy soil can tolerate weekly irrigation water salinity up to 6000 ppm with no significant reduction in most of vegetative growth characteristics and quality.

Key Words: *Cryptostegia grandiflora*, Irrigation water salinity.

INTRODUCTION

Cryptostegia grandiflora (*Nerium grandiflorum*, Roxbg.), a member of the Asclepiadaceae family, is a strong, evergreen (semi-deciduous in Egypt), twining woody climber, which grows to a height of 10 m or more. It has thick-textured, oval, glossy leaves, and funnel-shaped, reddish to lilac-purple flowers which appear in summer. Its stems yield poisonous latex that may cause severe discomfort if ingested (Brickell, 1999). In many parts of the world, it is known as the "rubber plant", and in India it is also known as pulay or palay, and is widely cultivated as an ornamental plant (Bailey, 1930). In addition, extracts of leaves of *Cryptostegia grandiflora* exhibited significant antibacterial activity against *Pseudomonas cepacia*, *Bacillus megatorium*, *B. subtilis*, *B. coagulans*, *Staphylococcus aureus* and *Escherichia coli* (Mukherjee *et al*., 1999). In another study, Augustus *et al*. (2000), evaluated *C. grandiflora* as a potential multi-use crop. They found that the plant contained 14.0% protein, 6.5% fixed oil, 6.9% polyphenol, and 2.13% hydrocarbon. The hydrocarbon fraction contains natural rubber. The high proportion of saturated fatty acids and the high oil content (> 5.0%) make *C. grandiflora* a potential source for industrial raw material and alternative for conventional oil.

In view of the different possible uses of *C. grandiflora*, it is strange that this plant is not relatively wide spread in Egypt. It is grown in a number of botanical gardens (including El-Zohreya and El-Orman Gardens, and – recently – in the Ornamental Plants Nursery, Faculty of Agriculture, Cairo University), but not in commercial nurseries. The potential of *C. grandiflora* for use in landscape purposes depends primarily on its ability to grow vigorously under stress coditions such as irrigation with saline water, since most of the landscape development in Egypt (new cities, touristic and coastal resorts, … etc.) takes place in newly-reclaimed desert areas. Such areas require enormous amounts of water for irrigation in order to ensure vigorous plant growth, since water shortage may have adverse effects on plants in the landscape, as it often results in an osmotic shock to the roots, which causes an immediate reduction in photosynthesis (Hoddinott *et al.*, 1979). This has made it necessary to use various sources of irrigation water, which often have relatively high salinity levels (such as well water or recycled municipal water). Salinity is known to have unfavourable effects on plant growth, which can be attributed to inhibition of water avalability mechanisms, disturbance of hormonal mechanisms within the plant, damage to plant cells and cytoplasmic organelles, and interference with normal metabolism (Meiri and Shalhavet, 1973). The adverse effect of high salinity levels on plant metabolism was emphasized by Taiz and Zeiger (1998), who stated that high concentrations of total salts inactivate enzymes and inhibit protein synthesis, and that photosynthesis is inhibited when high concentrations of Na^+ and/or Cl^- accumulate in chloroplasts.

It is, therefore, very important to select ornamental plants which tolerate irrigation water salinity. Several researchers such as Farahat *et al.* (1995) on *Acalypha macrophylla*, Song *et al.* (1997) on *Hibiscus syriacus* and *H. hamabo*, Wu *et al.* (2001) on *Pistacia chinensis*, *Nerium oleander*, *Buxus microphylla*, *Liquidambar styraciflua*, *Ceanothus thyrsiflorus*, *Nandina domestica*, *Rosa sp.*, *Jasminum polyanthum* and Mexican Stone Pine, and Hussein and Haggag (2003) on *Asclepias curassavica* studied the effect of irrigation water salinity on the growth of ornamental plants.

This study was conducted to evaluate the tolerance of *Cryptostegia grandiflora* grown in sandy soil to saline irrigation water.

MATERIALS AND METHODS

This study was conducted at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2006/2007 and 2007/2008. The aim of the study was to investigate the tolerance of *Cryptostegia grandiflora*, R. Br. plants to irrigation water salinity.

Seeds of *Cryptostegia grandiflora* were sown on 15th March 2006 and 2007 (in the first and second seasons, respectively), in a glasshouse in 8-cm plastic pots filled with a 1:1 (v/v) mixture of sand and clay. On 15th May 2006 and 2007 (in the two seasons, respectively), the seedlings (15 cm) were transplanted into perforated polyethylene bags (25-cm diameter) filled with sand + cattle manure (4:1, v/v) and moved outdoors to a sunny area on April 1st 2006 and 2007 (in the first and second seasons, respectively), then received monthly fertilization at the rate of 5 g/plant, using a compound chemical NPK fertilizer, with ratios of 3:1:1 (N : P_2O_5 : K_2O, 18 - 6- 6) as recommended by Hussein (2002). The sand was obtained from Giza desert, while the cattle manure was obtained from the Animal Production Department, Faculty of Agriculture, Cairo University. The physical and chemical characteristics of sand is shown in Table (1), while the physical and chemical characteristics of the cattle manure are presented in Table (2). One kilogram of NPK fertilizer was prepared by mixing 391.3 g urea (46% N), 387.1 g calcium superphosphate (15.5% P_2O_5), 125 g potassium sulphate (48% K_2O), and 96.6 g sand as an inert component.

The treatments were initiated 15 days later. The plants were irrigated weekly using tap water (control, 270 ppm) or saline water at concentrations of 3000, 6000, 9000 or 12000 ppm. 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 micro-tensiometers, and the quantity of water needed to reach 100% F.C. was calculated, as described by Richards (1949). On 1st August 2006 and 2007 (in the first and second seasons, respectively), wooden rods were inserted in the bags to support the plants.

The study consisted of 150 plants. The layout of the experiment was a randomized complete blocks design with three replicates for each treatment. Each replicate comprised ten plants.

On 1st April, 2007 and 2008 (in the two seasons, respectively), the experiment was terminated and the survival percentage was recorded. Also, vegetative growth parameters, including vine length, stem diameter (at 5 cm above soil surface), number of branches as well as fresh and dry weights of leaves, stems and roots/plant were recorded. In addition, chemical analysis of fresh leaf samples was conducted to determine their total chlorophylls content using the method described by Nornai (1982), while the content of total carbohydrates in dried leaf samples was determined using the method described by Dubois *et al.* (1956).

The contents of Na and Ca in the extract were determined by using a flame-photometer, while the Cl content was determined using the method described by Higinbothan *et al.* (1967). The proline content in fresh leaves was also determined using the method recommended by Bates *et al.* (1973).

The data on the vegetative growth characteristics and chemical compositions were subjected to statistical analysis of variance, and the means were compared using the "Least Significant Difference (L.S.D.)" test at the 5% level, as described by Little and Hills (1978). The survival percentage data was arcsine transformed, and the transformed data was statistically analysed.

Table (1): Physical and chemical characteristics of the soil used for growing *Cryptostegia grandiflora* plants during the 2006/2007 and 2007/2008 seasons.

Physical characteristics								
Soil texture	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	EC (dS/m)	Field capacity (%)	CEC (meq/100 g)
sand	30.6	60.6	4.3	4.5	0.62	0.94	19.9	5.30
Chemical characteristics								
pH	Organic matter (%)		Available macro-nutrients (ppm)					
			N		P		K	
7.8	1.34		19.5		2.11		97.8	

Table (2): Physical and chemical characteristics of the cattle manure used for growing *Cryptostegia grandiflora* plants during the 2006/2007 and 2007/2008 seasons.

Physical characteristics		Chemical characteristics								
Density (g/cm^3)	Humidity (%)	Organic matter (%)	EC (dS/m)	N (%)	P (%)	K (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
0.51	10.66	61.4	1.11	1.9	1.3	2.1	6.50	43	85	19

RESULTS AND DISCUSSION

1- Survival percentage

The results presented in Table (3) showed that irrigation water salinity had significant effect on the survival percentage of *Cryptostegia grandiflora* plants. In both seasons, increasing irrigation water salinity up to 6000 ppm caused no reduction in the survival percentage, compared to the control, but further increases in the salt concentration caused a steady reduction in the recorded values. However, this reduction was insignificant at a salt concentration of 9000 ppm (compared to the control), whereas higher salt concentration (12000 ppm) significantly reduced the recorded values, compared to the control.

The reduction in the survival percentage at high salinity levels may be attributed to three reasons: toxicity of one or more specific ions, osmotic inhibition of water absorption, and the combination of the two factors (Seatz *et al.*, 1958). Similar reductions in the survival percentage as a result of salt stress have been reported by El-Khateeb *et al.* (1991) on *Schinus molle*, Song *et al.* (1997) on *Hibiscus syriacus* and *H. hamabo* plants and Hussein and Haggag (2003) on *Asclepias curassavica* plants

2- Vegetative growth

The results recorded on *Cryptostegia grandiflora* plants (Tables 3-5) showed that the different growth parameters (vine length, stem diameter, number of branches as well as the fresh and dry weights of leaves, stems and roots/plant) were decreased steadily with increasing the salt concentration in the irrigation water to 3000, 6000, 9000 or 12000 ppm, as compared to the control plants irrigated with tap water.

Increasing salt concentration in irrigation water up to 9000 ppm insignificantly reduced vine length and fresh weights of leaves and roots whereas higher salt concentration (12000 ppm) caused significant reduction as compared to the control plants. Stem diameter, number of branches, dry weight of leaves as well as fresh and dry weights of stems were insignificantly decreased as a result of increasing salt concentrastion in irrigation water up to 6000 ppm, whereas higher salt concentrations (9000 - 12000 ppm) reduced them significantly, as compared to the control. Dry weight of roots was insignificantly decreased as a result of using the lowest salt concentration (3000 ppm) in irrigation water, meanwhile higher salt concentration (6000 - 12000 ppm) caused significant reduction as compared to the control plants irrigated with tap water.

The reduction in vine length as a result of high salt concentrations was explained by Everado *et al.* (1975), who suggested that the inhibitory effect of salinity on plant height might be due to the reduction in cell division and/or the inhibition of both cell elongation and activity of meristematic tissues. This may be attributed to a decrease in the activity levels of auxins and gibberellins within the plant, and/or an increase in the activity of growth inhibitors (Ghazi, 1976). Other explanations were proposed by Yasseen *et al.* (1987) and St. Arnaud and Vincent (1990), who mentioned that the decrease in plant height under saline conditions was probably due to the insufficient uptake of water and nutrients, as well as sodic toxicity.

The insignificant effect of the lowest salt concentrations (3000 - 6000 ppm) on most of the vegetative growth parameters is in agreement with the results obtained by Wu *et al.* (2001), who reported that a salt concentration of 500 or 1500 mg/litre caused no apparent salt stress symptoms on plants of *Pistacia chinensis*, *Nerium oleander*, *Buxus microphylla*, *Liquidambar styraciflua*, *Ceanothus thyrsiflorus*, *Nandina domestica*, *Rosa sp.*, *Jasminum polyanthum* and Mexican Stone Pine. Such result was reported by Hussein and Haggag (2003) on *Asclepias curassavica* plants.

On the other hand, the generally adverse effect of higher levels of irrigation water salinity is similar to those obtained by El-Leithy and El-Khateeb (1992) on *Thevetia nereifolia*, El-Khateeb (1994) on *Murraya* *exotica* seedlings, Song *et al.* (1997) on *Hibiscus syriacus* and *H. hamabo* and Hussein and Haggag (2003) on *Asclepias curassavica* plants.

3- Chemical composition

a- Total chlorophylls content

The total chlorophylls content in leaves of *Cryptostegia grandiflora* was also significantly affected by the salinity of the irrigation water (Table 5). In both seasons, the highest values (2.12 and 1.97 mg/g fresh matter in the first and second seasons, respectively) were obtained from plants irrigated using tap water (control). Raising the salt concentration to 3000, 60000, 9000, or 12000 ppm caused a steady reduction in the recorded values, with the highest salt concentration (12000 ppm) giving the lowest values (1.43 and 1.29 mg/g fresh matter in the two seasons, respectively). Generally, increasing salt concentration in irrigation water up to 6000 ppm insignificantly decreased total chlorophylls, whereas higher salt concentrations (9000 - 12000 ppm) significantly reduced the recorded values, as compared to the control. Similar reductions in the chlorophylls content were reported by Farahat (1990) on *Schinus molle, S. terebinthifolius* and *Myoporum acuminatum*, Shehata (1992) on *Cupressus sempervirens* and *Eucalyptus camaldulensis*, El-Khateeb (1994) on *Murraya exotica* and Hussein and Haggag (2003) on *Asclepias curassavica* plants as a result of irrigation using saline water.

Table (3): Effect of irrigation water salinity on survival percentage, vine length (cm) and stem diameter (mm) of *Cryptostegia grandiflora* plants in the 2006/2007 and 2007/2008 seasons.

Salt concentra-tions	*Survival percentage		Vine length (cm)		Stem diameter (mm)		Number of branches/ plant	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control (270 ppm)	100.0 a	100.0 a	221.8	198.6	23.8	21.7	12.6	14.1
3000 ppm	100.0 a	100.0 a	209.4	194.5	22.1	19.1	12.5	13.6
6000 ppm	100.0 a	100.0 a	205.2	178.6	19.8	18.5	11.9	12.4
9000 ppm	96.7 a	93.3 a b	196.1	176.3	18.0	15.0	6.0	8.0
12000 ppm	80.0 b	86.7 b	161.8	158.6	13.0	14.0	5.0	6.0
L.S.D. 0.05	--	--	30.1	26.5	4.3	3.8	1.5	1.8

*In each season in survival percentage, means sharing one or more letters are insignificantly different at 5% level, according to the "Least Significant Difference" test

b- Total carbohydrates content

The total carbohydrates content in leaves of *Cryptostegia grandiflora* was generally increased steadily by increasing the salt concentration in irrigation water (Table 5). Accordingly, the lowest values were obtained from plants irrigated with tap water, while the highest values were obtained with the highest salt concentration (12000 ppm). In the first season, incresing salt concentration in irrigation water up to 9000 ppm insignificantly increased total carbohydrates, whereas higher salt concentration (12000 ppm) significantly increased the recorded value, compared to the control. In the second season, increasing salt concentration up to 6000 ppm in irrigation water insignificantly increased total carbohydrates content, whereas higher salt concentrations (9000 - 12000 ppm) increased it significantly compared to the control. The increase in the total carbohydrates that was detected as a result of using saline irrigation water may be explained by the accumulation of carbohydrates more rapidly in plants grown under these conditions, compared to the rate of carbohydrate utilization for the different metabolic processes. A similar increase in the total carbohydrates in plants grown under saline conditions was obtained by Shehata (1992) on *Cupressus sempervirens* and *Eucalyptus camaldulensis*, Darwish (1994) on *Casuarina glauca* and Soliman (2008) on *Acacia nilotica*.

Table (4): Effect of irrigation water salinity on fresh and dry weights of leaves and stems (g) /plant of *Cryptostegia grandiflora* plants in the 2006/2007 and 2007/2008 seasons.

Salt concentrations	Fresh weight of leaves (g)/ plant		Dry weight of leaves (g)/ plant		Fresh weight of stems (g) / plant		Dry weight of stems (g)/ plant	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control (270 ppm)	68.3	61.8	13.65	14.82	98.8	110.5	29.64	31.89
3000 ppm	61.5	60.2	13.56	12.24	94.5	101.1	26.25	29.81
6000 ppm	57.0	54.0	10.80	11.88	87.1	96.9	25.01	27.48
9000 ppm	56.0	50.3	9.33	10.50	71.0	75.5	22.25	17.89
12000 ppm	32.7	41.1	9.15	8.18	65.3	56.1	16.39	14.73
L.S.D. 0.05	**12.9**	**12.2**	**2.95**	**3.11**	**13.4**	**15.2**	**4.93**	**4.61**

Table (5): Effect of irrigation water salinity on fresh and dry weights of roots (g)/plant, total chlorophylls (mg/ g fresh matter) and total carbohydrates (% dry matter) of *Cryptostegia grandiflora* plants in the 2006/2007 and 2007/2008 seasons.

Salt concentrations	Fresh weight of roots (g)/ plant		Dry weight of roots (g)/ plant		Total chlorophylls content (mg/g fresh matter)		Total carbohydrates (% dry matter)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control (270 ppm)	56.9	71.5	17.07	20.02	2.12	1.97	21.5	23.5
3000 ppm	54.1	65.1	15.15	18.88	1.89	1.79	22.8	26.8
6000 ppm	49.9	63.2	12.48	16.43	1.79	1.76	24.9	27.1
9000 ppm	47.1	58.9	12.25	14.73	1.68	1.33	25.6	33.5
12000 ppm	40.2	45.6	12.06	12.77	1.43	1.29	30.8	35.1
L.S.D. 0.05	**10.6**	**12.8**	**2.01**	**1.75**	**0.36**	**0.26**	**4.3**	**4.8**

C - Contents of Na, Ca and Cl

The results presented in Table (6) showed that, in general, the contents of Na, Ca and Cl in leaves of *Cryptostegia grandiflora* plants were significantly increased steadily with raising the salt concentration to 3000, 6000, 9000 or 12000 ppm as compared to the control plants irrigated with tap water. Accordingly, the lowest contents of the three nutrients were found in control plants, whereas the highest contents were found in plants irrigated with water containing the highest salt concentration. This increase in the Na, Ca and Cl contents as a result of raising the salt concentration may partly explain the reduction in the survival percentage under these conditions (as previously mentioned), since the accumulation of these elements at high concentrations may interfere with the mechanisms responsible for the closure of stomata, thus resulting in an increase in the rate of transpiration from the plant. This may eventually lead to plant wilting or death (Meidner and Mansfield, 1968). Increases in the Na, Ca and Cl contents with increasing the salinity level have been reported by El-Mahrouk *et al.* (1992) on *Dodonaea viscosa*, El-Khateeb (1994) on *Murraya exotica*, Farahat *et al.* (1995) on *Acalypha macrophylla* and Hussein and Haggag (2003) on *Asclepias curassavica* plants.

Table (6): Effect of irrigation water salinity on Na, Ca and Cl (% dry matter) as well as proline content (µ moles/ g fresh matter) of *Cryptostegia grandiflora* plants in the 2006/2007 and 2007/2008 seasons.

Salt concentrations	Na (% dry matter)		Ca (% dry matter)		Cl (% dry matter)		Proline content (µ moles/ g fresh matter)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control (270 ppm)	0.21	0.25	0.54	0.38	0.14	0.16	5.1	4.5
3000 ppm	0.28	0.30	0.89	0.60	0.18	0.22	8.6	9.8
6000 ppm	0.39	0.42	0.94	0.89	0.31	0.40	10.9	14.6
9000 ppm	0.51	0.60	1.15	1.04	0.40	0.52	22.1	20.8
12000 ppm	0.60	0.74	1.42	1.25	0.51	0.58	36.4	30.9
L.S.D. 0.05	**0.05**	**0.06**	**0.11**	**0.06**	**0.03**	**0.06**	**2.5**	**2.3**

c- Proline content

The data presented in Table (6) showed that the proline content in the leaves of *Cryptostegia grandiflora* plants was significantly increased steadily with increasing salt concentration in irrigation water, as compared to the control plants irrigated with tap water. Similar results were reported by El-Khateeb (1994) on *Murraya exotica* and Hussein and Haggag (2003) on *Asclepias curassavica* plants. The increase in the proline content under saline conditions may lead to the conclusion that proline plays a role in plant tolerance to salinity. This role was explained by Greenway and Munns (1980), who mentioned that proline can be considered as stabilizer of osmotic pressure within the cell. Also, Maraim (1990) and Marcum and Murdoch (1994) concluded that proline can make a substantial contribution to cytoplasmic osmotic adjustment. Moreover, Taiz and Zeiger (1998) mentioned that proline accumulates in the cytoplasm under conditions of stress, in order to maintain water potential equilibrium within the cells.

CONCLUSION

From the above results, it can be concluded that *Cryptostegia grandiflora* plants grown in sandy soil can tolerate weekly irrigation water salinity up to 6000 ppm with no significant reduction in most of vegetative growth characteristics and quality.

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تحمل نباتات *Cryptostegia grandiflora*, **R. Br.** النامية فى تربة رملية لملوحة مياه الرى

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أجرى هذا البحث فى مشتل التجارب بقسم بساتين الزينة، كلية الزراعة، جامعة القاهرة، خلال الموسمين المتتاليين ٢٠٠٦/٢٠٠٧ و٢٠٠٧/٢٠٠٨. وإستهدف البحث دراسة تحمل نباتات الـ *Cryptostegia grandiflora*, R. Br لملوحة مـاء الرى. تم رى النباتات (وصولا الى ١٠٠% من السعة الحقلية) أسبوعيا بإستخدام ماء الصنبور (كنترول، ٢٧٠ جزء فى المليون)، أو ماء يحتوى على خليط من أملاح كلوريد الصوديوم و كلوريد الكالسيوم (١:١ وزنا) بتركيـزات ٣٠٠٠، ٦٠٠٠، ٩٠٠٠ أو ١٢٠٠٠ جزء فى المليون.

أدى زيادة تركيز الملوحة فى ماء الرى حتى ٩٠٠٠ جزء فى المليون لإنخفاض غير معنوى فـى نسبة البقاء، وطول المتسلق والوزن الطازج للأوراق والجذور، بينما أدى إستخدام تركيزات ملوحـة حتـى ٦٠٠٠ جزء فى المليون لإنخفاض غير معنوى فى قطر الساق وعدد الأفرع والـوزن الجـاف لـلأوراق والوزن الطازج والجاف للسيقان وكذلك محتوى الكلوروفيل الكلى مقارنة بـالكنترول. أدى زيـادة تركيـز الملوحة لزيادة محتوى الكربوهيدرات الكلية والصوديوم والكالسيوم والكلورين والبرولين مقارنة بالكنترول.

من النتائج السابقة يتضح أن نباتات الـ *Cryptostegia grandiflora* النامية فى تربـة رمليـة تتحمل الرى أسبوعيا بماء مالح حتى تركيز ٦٠٠٠ جزء فى المليون، و ذلك دون حدوث إنخفاض معنوى فى صفات النمو الخضرى أو الجودة.