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EFFECT OF IRRIGATION INTERVALS AND SALT CONCENTRATIONS ON THE GROWTH AND CHEMICAL COMPOSITION OF *ASCLEPIAS CURASSAVICA* L.

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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 2000/2001 and 2001/2002. The aim of this study was to investigate the response of *Asclepias curassavica* plants to different irrigation intervals and irrigation with saline water. The plants were irrigated (till 100% of field capacity) every 3, 6, 9 or 12 days using tap water (control, 270 ppm) or water containing a mixture of NaCl and $CaCl_2$ (1:1 w/w) at concentrations of 1500, 3000, 4500, 6000 or 7500 ppm. The recorded data included the survival percentage, plant height, stem diameter, as well as the fresh and dry weights of leaves, stems and roots/plant. Also, chemical analysis of the leaves was conducted to determine their contents of total chlorophylls, total carbohydrates, proline, Na, Cl and Ca. The most important results are summarized as follows:

- Prolonging the irrigation intervals to 9 or 12 days caused significant reductions in the survival percentage and all of the vegetative growth parameters, compared to irrigation every 3 days.
- Salt concentrations of 4500-7500 ppm significantly reduced the survival percentage, while salt concentrations of 3000-7500 ppm reduced most of the tested vegetative growth parameters significantly, compared to the control.
- Prolonging the irrigation intervals and raising the salt concentration in the irrigation water decreased the values recorded for the different vegetative growth parameters. No significant reduction was detected for most of the studied growth characteristics when the plants were irrigated every 3 days using a salt concentration of 1500 ppm, or every 6 days using tap water, compared to plants irrigated every 3 days using tap water.
- In general, prolonging the irrigation intervals and/or raising the salt concentrations reduced the total chlorophylls content steadily and increased the proline content. The total carbohydrates content was increased gradually by prolonging the irriga-

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tion intervals, but was reduced by high salt concentrations (3000-7500 ppm), compared to the control. The Na, Cl and Ca contents were reduced steadily by prolonging the irrigation intervals, but were increased by raising the salt concentration.

From the above results, it can be concluded that *Asclepias curassavica* plants can be irrigated every 6 days using tap water, or every 3 days using saline water with concentrations up to 1500 ppm, without any significant reduction in growth.

Key Words: *Asclepias curassavica*, Irrigation intervals, Salinity

INTRODUCTION

Asclepias curassavica (Family Asclepiadaceae) is an evergreen subshrub native to South America. It reaches a height of approximately 1 m, with upright branches and opposite, elliptic-lance-shaped, mid-green leaves (up to 15 cm long). The flowers are carried in axillary or near terminal, umbel-like cymes, and are red or orange-red, sometimes yellow or white, with orange-yellow hoods. The plants flower from summer to autumn, and flowering is followed by the formation of erect fruits of up to 8 cm in length (**Brickell, 1996**).

In addition to its use for landscape purposes as a flowering ornamental plant, *A. curassavica* has shown a number of medicinal properties. For example, cardiotonic activity was found in the leaves (**Carbajal *et al* 1991**), while the latex showed antifungal activity against *Candida albicans* (**Giordani *et al* 2000**). Also, cardenolides, free sterols, triacylglycerols, triterpenyl acetates, steryl- and triterpene esters were found in the plants, especially in the latex [**Groeneveld *et al* (1990, 1991 and 1994)**]. In addition, *A. curassavica* was tested for large scale cultivation as an alternative source of renewable intermediate energy, rubber and phytochemicals (**Marimuthu *et al* 1989**).

In Egypt, the large scale land reclamation activities 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 availability 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 with low water requirements and a high tolerance to salinity. Several researchers have conducted studies on the effect of different irrigation regimes [**Williams *et al* (1999)** on *Rosa X hybrida*, **Rizzitelli *et al* (2000)** on *Eunymus japonicus*, *Viburnum tinus*, *Pittosporum tobira* and *Osmanthus heterophyllus*, and **Hammam (2002)** on *Cassia acutifolia*] and irrigation water salinity [**Farahat *et al* (1995)** on *Acalypha macrophylla*, **Song *et al* (1997)** on *Hibiscus syriacus* and *H. hamabo*, and **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] on the growth of ornamental plants.

This study was conducted to test the suitability of *A. curassavica* plants for cultivation under conditions of water shortage, and to determine their tolerance to saline irrigation water.

MATERIAL 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 2000/2001 and 2001/2002. The aim of the study was to investigate the effect of different irrigation intervals and irrigation water salinity on the growth and chemical composition of *Asclepias curassavica* L plants.

Seeds of *Asclepias curassavica* were sown on 15th March 2000 and 2001 (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, in both seasons, the seedlings (15 cm tall) were transplanted into perforated polyethylene bags (30-cm diameter) filled with 6 kg of a clay loam soil, obtained from the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University. The physical and chemical characteristics of the soil are shown in Table (1).

In the first week of June, in both seasons, the seedlings were moved outdoors to a sunny area, and the treatments were initiated 15 days later. The plants were irrigated every 3, 6, 9 or 12 days using tap water (control, 270 ppm) or saline water at concentrations of 1500, 3000, 4500, 6000 or 7500 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 microtensiometers, and the quantity of water needed to reach 100% F.C. was calculated, as described by **Richards (1949)**. The treatments were applied regularly until the termination of each season. All plants received monthly fertilization using Kristalon NPK fertilizer (19-19-19) at the rate of 3 g/plant, starting 15th August 2000 and 2001 (in the first and second seasons, respectively).

The layout of the experiment was a split-plot design, with the main plots arranged in a randomized complete blocks design, with 3 blocks (replicates). The main plots were assigned to the irrigation intervals, while the sub-plots were assigned to the irrigation water salinity treatments. The study included 24 treatments [4 irrigation intervals X 6 salt concentrations (including the control)], with each block consisting of 240 plants (10 plants/treatment).

On 1st July, 2001 and 2002 (in the two seasons, respectively), the experiment

Table 1. Physical and chemical characteristics of the potting soil used for growing *Asclepias curassavica* during the 2000/2001 and 2001/2002 seasons

Physical characteristics								
Soil texture	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	EC (dS/m)	Field capacity (%)	CEC (meq/100 g)
Clay loam	8.2	31.6	26.7	33.5	2.4	0.34	45.9	34.5

Chemical characteristics				
pH	Organic matter (%)	Available macro-nutrients (ppm)		
		N	P	K
7.6	1.34	42.0	9.2	387.0

was terminated and the survival percentage was recorded. Also, vegetative growth parameters, including plant height, stem diameter (at 15 cm above soil surface), as well as fresh and dry weights of stems, leaves 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)**.

Also, nutrients were extracted from samples of dried leaves, using the method described by **Piper (1947)**. The contents of Na and Ca in the extract were determined by using a Pye Unicam Model SP 1900 Atomic Absorption Spectrophotometer, 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 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.

RESULTS AND DISCUSSION

1- Survival percentage

The results presented in Table (2) show that irrigation intervals and salt concentrations had significant effects on the survival percentage of *Asclepias curassavica* plants. In both seasons, prolonging the irrigation intervals resulted in a steady reduction in the mean survival percentage. However, this reduction was insignificant when the irrigation intervals were prolonged from 3 to 6 days, while longer irrigation intervals (9 or 12 days) significantly decreased the

Table (2): Effect of irrigation intervals and salt concentrations on the survival percentage, plant height and stem diameter of *Asclepias curassavica* plants during the 2000/2001 and 2001/2002 seasons.

Irrigation intervals (I)	First season (2000/2001)							Second season(2001/2002)						
	Salt concentrations (S), ppm							Salt concentrations (S), ppm						
	Control	1500	3000	4500	6000	7500	**Means**	Control	1500	3000	4500	6000	7500	**Means**
							***Survival percentage**							
3 days	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	96.7 ab	**99.5 a**	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	90.0 a-c	**98.3 a**
6 days	100.0 a	100.0 a	100.0 a	100.0 a	80.0 bc	80.0 bc	**93.3 ab**	100.0 a	100.0 a	100.0 a	100.0 a	90.0 a-c	83.3 b-d	**95.6 a**
9 days	100.0 a	100.0 a	100.0 a	83.3 a-c	70.0 b-d	66.7 cd	**86.7 bc**	100.0 a	100.0 a	100.0 a	80.0 b-d	70.0 cd	60.0 de	**85.0 b**
12 days	100.0 a	100.0 a	86.7 a-c	70.0 b-d	60.0 cd	50.0 d	77.8 c	100.0 a	100.0 a	96.7 ab	73.3 cd	66.7 de	43.3 e	**80.0 b**
Means	**100.0 a**	**100.0 a**	**96.7 ab**	**88.3 bc**	77.5 cd	**73.4 d**	---	**100.0 a**	**100.0 a**	**99.2 a**	**88.3 b**	**81.7 b**	**69.2 c**	---
							Plant height (cm)							
3 days	110.8	105.7	100.3	86.5	65.6	59.3	**88.0**	121.0	115.8	104.7	81.5	80.7	70.1	**95.6**
6 days	99.1	94.2	88.7	81.0	61.1	54.8	**79.8**	116.3	112.7	99.8	65.6	61.0	54.3	**85.0**
9 days	84.4	80.4	78.2	75.1	44.5	39.3	**67.0**	110.5	100.3	69.0	54.7	46.1	33.7	**69.1**
12 days	76.9	70.5	69.6	59.2	40.7	31.5	**58.1**	93.1	85.9	66.9	49.2	40.4	29.9	**60.9**
Means	**92.8**	**87.7**	**84.2**	**75.5**	**53.0**	**46.2**	---	**110.2**	**103.7**	**85.1**	**62.8**	**57.1**	**47.0**	---
L.S.D. (0.05)														
I				8.5							11.0			
S				9.1							11.5			
I X S				9.8							11.9			
							Stem diameter (mm)							
3 days	28.9	25.6	23.4	23.0	20.2	18.5	**23.3**	33.6	30.4	28.3	25.8	22.1	17.2	**26.2**
6 days	27.8	25.0	21.1	20.3	17.6	15.6	**21.2**	31.2	27.8	27.1	25.3	18.6	15.5	**24.3**
9 days	26.4	23.8	19.9	18.0	17.1	14.2	**19.9**	28.5	25.6	23.0	19.4	15.0	15.1	**21.0**
12 days	24.7	21.1	18.2	15.1	14.4	13.0	**17.8**	25.9	25.0	20.1	15.6	15.0	14.0	**19.3**
Means	**27.0**	**23.9**	**20.7**	**19.1**	**17.3**	**15.3**	---	**29.8**	**27.2**	**24.6**	**21.5**	**17.7**	**15.5**	---
L.S.D. (0.05)														
I				2.5							2.4			
S				3.3							3.5			
I X S				3.7							4.1			

*Within the row for salinity treatment means, the column for irrigation interval means, or the means for combinations of the two factors, means sharing one or more letters are insignificantly different at the 5% level, according to the "Least Significant Difference" test.

survival percentage, compared to values recorded for plants irrigated at the shortest intervals (every 3 days). Similar decreases in the survival percentage were obtained by **Humphries** ***et al*** **(1982)** on *Betula pendula*, and **El-Khateeb** ***et al*** **(1991)** on *Schinus molle*, as a result of prolonging the irrigation intervals. No significant difference was obtained between the survival percentages of plants irrigated every 9 or 12 days (in both seasons). Also, no significant difference was obtained in the first season between the survival percentages of plants irrigated every 6 or 9 days.

A salt concentration of 1500 ppm in the irrigation water 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 3000 ppm (compared to the control), whereas higher salt concentrations (4500-7500 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*, and **Song** ***et al*** **(1997)** on *Hibiscus syriacus* and *H. hamabo* plants.

Regarding the interaction between the effects of irrigation intervals and salt concentrations on the survival percentage, the results recorded in the two seasons (Table 2) show that among plants irrigated at each of the tested intervals, no significant difference was detected between the survival percentage of plants irrigated with tap water and that of plants receiving salt concentrations of 1500 or 3000 ppm. However, the effect of higher salinity levels (4500-7500 ppm) differed from one irrigation interval to the other. With frequent irrigation (every 3 days), salinity had no significant effect on the survival percentage, even at the highest salt concentration (7500 ppm). On the other hand, as the irrigation intervals were prolonged, the plants became more susceptible to salinity. Accordingly, plants irrigated at the longest intervals (12 days) were the most susceptible to salinity. In both seasons, these plants showed significant reductions in the survival percentage when the irrigation water had a salt concentration of 4500-7500 ppm. The above results can be easily explained, since the long irrigation intervals allow the soil to dry out and, consequently, the concentration of soil solution becomes much higher than the original concentration of the irrigation water. This increase in the concentration of the soil solution may cause partial plasmolysis of the root cells, thus affecting their ability to perform their physiological functions of absorption of water and nutrients.

The data in Table (2) also show that plants irrigated with water containing salt concentrations of up to 3000 ppm showed no significant reduction in the survival percentage when the irrigation intervals were prolonged from 3 to 6, 9 or 12 days. On the other hand, plants irrigated with water containing higher salt concentrations (4500-7500 ppm) were more sensitive to prolonging the irrigation intervals, i.e. as the salt concentration was increased, the plants needed irrigation at short intervals in order to avoid any significant reduction in the survival percentage. For example, plants irrigated with saline water at the highest concentration (7500 ppm) showed no significant difference in the values recorded at relatively short irrigation intervals (3 or 6 days), but longer irrigation intervals (9 or 12 days) reduced the survival percentage significantly (in both seasons), compared to plants irrigated with 7500 ppm every 3 days. These results are in agreement with the findings of **El-Khateeb *et al* (1991)**, who reported that the survival percentage of *Schinus molle* plants was decreased by combining long irrigation intervals with high salt concentrations in the irrigation water.

It can be concluded that if *Asclepias curassavica* plants are irrigated using saline water at concentrations of up to 3000 ppm, the irrigation intervals can be prolonged up to 12 days with no significant reduction in the survival percentage, but if the salt concentration is higher (4500-7500 ppm), the plants should be irrigated at shorter intervals in order to maintain a high survival percentage.

2- Vegetative growth

a- Effect of irrigation intervals

The results recorded on *Asclepias curassavica* plants (Tables 2-4) show that the different growth parameters (plant height, stem diameter, as well as the fresh and dry weights of leaves, stems and roots/plant) were decreased steadily with prolonging the irrigation intervals. In most cases, prolonging the irrigation intervals from 3 to 6 days caused only a slight (insignificant) reduction in the growth characteristics of the aboveground plant parts, but longer irrigation intervals (9 or 12 days) resulted in significant reductions in the mean values recorded for these characteristics, compared to the values recorded with irrigation every 3 days. The only exception to this general trend was detected in the first season, with plants irrigated every 6 days having a dry weight of leaves that was significantly lower than that recorded for plants irrigated every 3 days. On the other hand, the growth of the roots was more sensitive to changes in the irrigation intervals, compared to the growth of aboveground parts. In the first season, even the increase in the irrigation intervals from 3 to 6 days caused significant reductions in the fresh and dry weights of roots/plant. Also, prolonging the irrigation intervals from 3 to 6 days in the second season significantly reduced the dry weight of roots/plant, but had no significant effect on the fresh weight of roots/plant. Longer irrigation intervals (9 or 12 days) caused a more pronounced reduction in root growth, with plants irrigated at these intervals giving significantly lower values for the fresh and dry weights of roots /plant, compared to plants irrigated every 3 or 6 days.

The reduction in vegetative growth as a result of prolonging irrigation intervals is in agreement with the findings of **El-Khateeb *et al* (1991)**, who reported that the different growth characteristics of *Schinus molle* plants (plant height, stem diameter, as well as the fresh and dry weights of leaves and roots) were decreased by prolonging the irrigation intervals. In another study, **Nash and Graves (1993)** found that the shoot and root dry weights of *Acer rubrum*, *Magnolia virginiana*, *Nyssa sylvatica*, *Taxodium distichum* and *Asimina triloba* plants were significantly reduced by

Table (3): Effect of irrigation intervals and salt concentrations on the fresh weights of stems, leaves and roots/plant of *Asclepias curassavica* plants during the 2000/2001 and 2001/2002 seasons.

Irrigation intervals (I)	First season (2000/2001) Salt concentrations (S), ppm							Second season(2001/2002) Salt concentrations (S), ppm						
	Control	1500	3000	4500	6000	7500	**Means**	Control	1500	3000	4500	6000	7500	**Means**
							Fresh weight of stems/plant (g)							
3 days	82.0	78.6	70.0	59.4	52.3	40.7	**63.8**	100.5	98.1	82.4	74.2	53.1	47.9	**76.1**
6 days	78.7	71.2	65.6	53.0	44.1	36.3	**58.2**	98.4	93.6	81.1	69.1	49.4	44.2	**72.6**
9 days	64.3	63.0	51.4	48.0	36.9	26.1	**48.3**	80.1	76.2	65.1	50.6	34.8	24.8	**55.3**
12 days	61.2	59.8	46.9	40.0	24.8	19.2	**42.0**	65.2	60.6	49.8	35.7	29.0	15.5	**42.6**
Means	**71.6**	**68.2**	**58.5**	**50.1**	**39.5**	**30.6**	—	**86.1**	**82.1**	**69.6**	**57.4**	**41.6**	**33.1**	—
L.S.D. (0.05)														
I				6.0							5.1			
S				6.8							5.8			
I X S				7.3							6.1			
							Fresh weight of leaves/plant (g)							
3 days	63.5	59.9	45.1	30.6	24.5	19.0	**40.4**	54.9	52.7	45.3	34.5	23.1	19.2	**38.3**
6 days	60.8	52.8	40.9	28.1	21.9	15.9	**36.7**	49.8	47.0	43.9	30.6	21.4	16.9	**34.9**
9 days	45.9	39.9	24.6	18.3	13.4	9.0	**25.2**	38.4	36.6	31.0	23.1	15.0	14.4	**26.4**
12 days	30.8	31.6	19.9	13.3	9.7	8.1	**18.9**	32.0	27.9	22.6	18.3	15.3	12.6	**21.5**
Means	**50.3**	**46.0**	**32.6**	**22.6**	**17.4**	**13.0**	—	**43.8**	**41.1**	**35.7**	**26.6**	**18.7**	**15.8**	—
L.S.D. (0.05)														
I				3.8							3.5			
S				4.5							3.8			
I X S				4.9							4.3			
							Fresh weight of roots/plant (g)							
3 days	61.8	58.7	52.0	49.6	42.6	26.8	**48.6**	62.0	60.9	51.0	41.0	35.6	30.2	**46.8**
6 days	57.0	56.1	46.4	40.2	36.5	25.4	**43.6**	59.9	57.8	48.4	39.7	34.9	30.0	**45.1**
9 days	50.1	48.0	39.5	32.8	28.5	25.0	**37.3**	54.7	50.2	38.4	27.5	20.1	15.7	**34.4**
12 days	40.7	35.8	38.4	30.0	26.0	25.0	**32.7**	46.4	39.8	37.3	20.5	12.2	11.0	**27.9**
Means	**52.4**	**51.9**	**44.1**	**38.2**	**33.4**	**25.6**	—	**55.8**	**52.2**	**43.8**	**32.2**	**25.7**	**21.7**	—
L.S.D. (0.05)														
I				2.2							2.0			
S				2.8							3.7			
I X S				3.1							3.9			

Table (4): Effect of irrigation intervals and salt concentrations on the dry weights of stems, leaves and roots/plant of *Asclepias curassavica* plants during the 2000/2001 and 2001/2002 seasons.

Irrigation intervals (I)	First season (2000/2001) Salt concentrations (S), ppm							Second season(2001/2002) Salt concentrations (S), ppm						
	Control	1500	3000	4500	6000	7500	Means	Control	1500	3000	4500	6000	7500	Means
							Dry weight of stems/plant (g)							
3 days	18.4	18.0	16.9	12.9	10.2	7.5	**13.9**	18.5	17.2	16.1	14.6	13.2	9.8	**14.9**
6 days	18.0	17.7	15.9	11.8	8.9	6.8	**13.1**	17.8	16.6	15.8	13.0	12.3	8.2	**14.0**
9 days	17.8	16.9	15.0	9.5	7.3	5.0	**11.9**	15.2	14.9	13.1	12.2	9.3	6.0	**11.8**
12 days	16.5	15.8	12.5	6.8	6.0	4.6	**10.4**	14.4	13.7	12.1	10.9	7.6	4.3	**10.5**
Means	**17.7**	**17.1**	**15.1**	**10.3**	**8.1**	**6.0**	---	**16.5**	**15.6**	**14.3**	**12.7**	**10.6**	**7.1**	---
L.S.D. (0.05)														
I				1.1							1.0			
S				1.3							1.6			
I X S				1.8							2.0			
							Dry weight of leaves/plant (g)							
3 days	9.6	8.7	5.6	4.1	3.5	3.1	**5.8**	9.2	8.5	6.9	4.3	3.8	2.3	**5.8**
6 days	9.0	8.5	5.0	4.1	3.1	2.9	**5.4**	8.9	7.9	6.6	3.9	3.4	2.0	**5.5**
9 days	8.0	6.2	4.4	3.5	2.5	2.0	**4.4**	7.7	6.0	4.9	4.0	3.0	1.7	**4.6**
12 days	7.6	5.8	3.7	2.9	2.1	1.6	**4.0**	7.4	5.3	4.4	3.5	2.6	1.6	**4.1**
Means	**8.6**	**7.3**	**4.7**	**3.7**	**2.8**	**2.4**	---	**8.3**	**6.9**	**5.7**	**3.9**	**3.2**	**1.9**	—
L.S.D. (0.05)														
I				0.3							0.4			
S				0.5							0.6			
I X S				0.7							0.7			
							Dry weight of roots/plant (g)							
3 days	18.0	17.3	16.0	13.2	12.3	10.3	**14.5**	18.9	18.0	15.7	11.7	11.1	10.0	**14.2**
6 days	16.5	16.0	14.3	12.8	11.8	9.3	**13.5**	17.6	16.9	14.8	11.9	9.6	7.9	**13.1**
9 days	14.5	13.5	12.3	12.0	10.0	8.0	**11.7**	16.0	13.8	10.5	8.5	6.6	4.6	**10.0**
12 days	13.0	12.5	12.3	10.8	9.3	7.5	**10.9**	15.2	12.9	9.9	6.8	4.5	3.8	**8.9**
Means	**15.5**	**14.8**	**13.7**	**12.2**	**10.9**	**8.8**	---	**16.9**	**15.4**	**12.7**	**9.7**	**8.0**	**6.6**	---
L.S.D. (0.05)														
I				0.6							0.9			
S				0.8							1.7			
I X S				0.9							1.9			

drought. Moreover, **Rober and Horn (1993)** detected a reduction in the vegetative growth of *Euphorbia pulcherrima* under conditions of water shortage, while **Harris and Bassuk** (1995) found that *Corylus colurna* seedlings subjected to drought had smaller diameter trunks. Also, **Williams *et al*** (1999) reported that miniature rose plants (*Rosa X hybrida*) produced with a water deficit were more compact than control plants. Recently, **Rizzitelli *et al* (2000)** mentioned that water deficit markedly affected plant growth in *Eunymus japonicus*, *Viburnum tinus*, *Pittosporum tobira* and *Osmanthus heterophyllus*.

b- Effect of irrigation with saline water

Increasing the salt concentration in the irrigation water also had an adverse effect on the growth of *Asclepias curassavica* plants. In both seasons, the mean values recorded for the different growth characteristics were reduced steadily as the salt concentration was raised to 1500, 3000, 4500, 6000 or 7500 ppm. However, the reduction in the mean values recorded for most of the studied parameters was insignificant at the lowest salt concentration (1500 ppm) as compared to the control, whereas higher salt concentrations (3000-7500 ppm) resulted in significant reduction in the values recorded for most of the growth characteristics. The dry weight of leaves/plant was the only growth characteristic that showed a significant reduction in both seasons as a result of using the lowest salt concentration (1500 ppm), compared to the control.

The reduction in plant height 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 concentration (1500 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. 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, and **Song *et al* (1997)** on *Hibiscus syriacus* and *H. hamabo*.

c- Interaction between effects of irrigation intervals and salt concentrations

The data recorded in the two seasons (Tables 2-4) show that the most vigorous vegetative growth of *Asclepias curassavica* plants (i.e., the highest values for the different vegetative growth characteristics) was obtained as a result of irrigation every 3 days using tap water (control). In most cases, prolonging the irrigation intervals and/or raising the salt concentration in the irrigation water decreased the values recorded for the different growth parameters. However, this reduction was insignificant (in most of the studied characteristics) when the plants were irrigated every 3 days using a salt concentration of 1500 ppm, compared to plants irrigated every 3 days using tap water. This effect was clear in the data recorded in both seasons for plant height, stem diameter, fresh weight of leaves/plant, fresh and dry weights of stems/plant, and dry weight of roots/plant. A similar result was also recorded for the fresh weight of roots/plant in the second season. These results are in agreement with the findings of **Warmenhoven *et al* (1995)**, who reported that the reduction in chrysanthemum growth from high NaCl concentrations was less marked with a high irrigation frequency.

Also, most of the studied growth characteristics showed no significant reduction in the recorded values (compared to plants irrigated every 3 days using tap water) when the irrigation intervals were prolonged from 3 to 6 days, without adding any salt in the irrigation water (i.e., plants were irrigated with tap water). In both seasons, this was evident in data recorded for stem diameter, dry weight of leaves/plant, as well as the fresh and dry weights of stems/plant. This effect was also evident in the first season for the fresh weight of leaves/plant, and in the second season for plant height, and the fresh and dry weights of roots/plant.

On the other hand, the values recorded for most of the studied characteristics were decreased significantly (compared to plants irrigated every 3 days using tap water) when the irrigation water contained salt concentrations of 3000-7500 ppm, regardless of the irrigation intervals. Moreover, when the lowest salt concentration (1500 ppm) was combined with irrigation intervals of 6, 9 or 12 days, most of the studied parameters were decreased significantly. Also, plants irrigated every 9 or 12 days gave significantly lower values for most of the studied characteristics (regardless of the salt concentration), compared to plants irrigated every 3 days using tap water. These results are similar to those obtained by **El-Khateeb *et al* (1991)**, who reported that combining long irrigation intervals (12 days) with a high salinity level (8000 ppm) reduced plant height, stem diameter, as well as the fresh and dry weights of roots of *Schinus molle* plants.

From the above results, it can be concluded that although the most vigorous growth of *Asclepias curassavica* plants can be obtained with irrigation every 3 days using tap water, but irrigation every 6 days using tap water, or every 3 days using a salt concentration of 1500 ppm, caused no significant reduction of vegetative growth.

3- Chemical composition

a- Total chlorophylls content

The data presented in Table (5) show that irrigation intervals had a considerable effect on the total chlorophylls content in leaves of *Asclepias curassavica*. In both seasons, prolonging the irrigation intervals from 3 to 6, 9 or 12 days resulted in a steady reduction in the total chlorophylls content. Accordingly, the highest

Table (5): Effect of irrigation intervals and salt concentrations on the total chlorophylls, total carbohydrates and proline contents in leaves of *Asclepias curassavica* plants during the 2000/2001 and 2001/2002 seasons.

Irrigation intervals (I)	First season (2000/2001) Salt concentrations (S), ppm							Second season(2001/2002) Salt concentrations (S), ppm						
	Control	1500	3000	4500	6000	7500	**Means**	Control	1500	3000	4500	6000	7500	**Means**
							Total chlorophylls content (mg/g fresh matter)							
3 days	2.13	2.09	1.96	1.59	1.50	1.27	**1.76**	2.33	2.12	2.11	1.70	1.58	1.40	**1.87**
6 days	2.11	1.95	1.85	1.44	1.39	1.25	**1.67**	2.12	2.01	1.95	1.61	1.44	1.32	**1.74**
9 days	1.99	1.90	1.76	1.28	1.26	1.11	**1.55**	2.08	2.01	1.78	1.48	1.34	1.30	**1.67**
12 days	1.85	1.81	1.50	1.23	1.15	0.80	**1.39**	1.80	1.65	1.65	1.30	1.30	1.25	**1.49**
Means	**2.02**	**1.94**	**1.77**	**1.39**	**1.33**	**1.11**	---	**2.08**	**1.95**	**1.87**	**1.52**	**1.42**	**1.32**	---
							Total carbohydrates content (% dry matter)							
3 days	17.0	18.0	14.0	11.7	10.9	9.0	**13.4**	21.6	20.0	18.0	15.0	14.6	12.0	**16.9**
6 days	18.3	18.9	16.4	16.0	14.1	11.0	**15.8**	24.0	21.0	20.0	15.8	15.4	12.5	**18.1**
9 days	19.0	19.3	17.9	16.0	15.0	14.0	**16.9**	24.9	22.9	20.0	19.2	18.3	14.5	**20.0**
12 days	21.8	24.3	20.8	16.0	15.5	15.5	**19.0**	30.8	26.0	22.4	21.8	20.4	16.6	**23.0**
Means	**19.0**	**20.1**	**17.3**	**14.9**	**13.9**	**12.4**	---	**25.3**	**22.5**	**20.1**	**18.0**	**17.2**	**13.9**	---
							Proline content (μ moles/g fresh matter)							
3 days	2.3	4.0	5.4	9.6	10.0	15.8	**7.9**	2.1	2.3	4.6	6.1	9.9	17.5	**7.1**
6 days	4.0	6.0	12.4	24.0	28.9	30.5	**17.6**	6.4	8.1	8.5	9.9	12.0	18.1	**10.5**
9 days	8.3	10.5	12.6	27.0	35.5	38.0	**22.0**	6.6	9.3	13.8	21.6	30.0	40.3	**20.3**
12 days	11.0	21.2	21.6	28.0	46.1	55.1	**30.5**	9.0	15.3	16.7	31.2	34.4	48.3	**25.8**
Means	**6.4**	**10.4**	**13.0**	**22.2**	**30.1**	**34.9**	---	**6.0**	**8.8**	**10.9**	**17.2**	**21.6**	**31.1**	---

mean values (1.76 and 1.87 mg/g fresh matter in the first and second seasons, respectively) were obtained from plants irrigated at the shortest intervals (3 days), whereas the lowest values (1.39 and 1.49 mg/g fresh matter in the two seasons, respectively) were obtained from plants irrigated at the longest intervals (12 days). This reduction in the chlorophylls content as a result of prolonging the irrigation intervals is in agreement with the findings of **Hammam (2002)** on *Cassia acutifolia*.

The total chlorophylls content was also affected considerably by the salinity of the irrigation water. In both seasons, the highest mean values (2.02 and 2.08 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 1500, 3000, 4500, 6000 or 7500 ppm caused a steady reduction in the recorded values, with the highest salt concentration (7500 ppm) giving the lowest mean values (1.11 and 1.32 mg/g fresh matter in the two seasons, respectively). 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*, and **El-Khateeb (1994)** on *Murraya exotica* as a result of irrigation using saline water.

Regarding the interaction between the effects of irrigation intervals and salt concentrations, the data recorded in both seasons (Table 5) show that the highest total chlorophylls contents (2.13 and 2.33 mg/g fresh matter in the first and second seasons, respectively) were obtained from plants irrigated at the shortest intervals (3 days) using tap water (control), whereas the lowest values (0.80 and 1.25 mg/g fresh matter in the two seasons, respectively) were obtained when irrigation at the longest intervals (12 days) was combined with the highest salt concentration (7500 ppm).

b- Total carbohydrates content

The mean total carbohydrates content in leaves of *Asclepias curassavica* was generally increased steadily by prolonging the irrigation intervals. (Table 5). Accordingly, the lowest values were obtained from plants irrigated at the shortest intervals (3 days), while the highest values were obtained with the longest irrigation intervals (12 days). This behaviour may be attributed to a reduction of carbohydrates translocation from leaves to other plant parts under drought conditions and/or the lesser consumption of carbohydrates in the leaves [**El-Khateeb *et al* (1991)** on *Schinus molle*].

The data in Table (5) also show that the lowest salt concentration (1500 ppm) increased the total carbohydrates content in the first season, but decreased it in the second season, compared to the control. The increase in the total carbohydrates content that was detected in the first season as a result of using a salt concentration of 1500 ppm 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 leaves of plants grown under saline conditions was obtained by **Darwish (1994)** on *Casuarina glauca*.

On the other hand, all higher salt concentrations (3000-7500 ppm) gave lower values than the control in both seasons. Moreover, the results recorded in both seasons show that raising the salt concentration from 1500 to 3000, 4500, 6000 or 7500 ppm caused a steady decrease in the total carbohydrates contents. Accordingly the lowest values recorded in both seasons were found in plants receiving the highest salt concentration (7500 ppm), regardless of the irrigation intervals. This reduction in the total carbohydrates content of plants irrigated using saline water (at 3000-7500 ppm) may be attributed to the production of relatively high energy by increasing respiration to overcome the relatively low availability of water under saline conditions (**Moursi *et al* 1976**). Similar reductions in the total carbohydrates content have been recorded by **El-Khateeb *et al* (1991)** on *Schinus molle* plants as a result of raising the salt concentration in the irrigation water.

Regarding the effect of different combinations of irrigation intervals and salt concentrations, it is clear from the results presented in Table (5) that the highest total carbohydrates content was obtained when irrigation every 12 days was combined with using a salt concentration of 1500 ppm (in the first season) or tap water (in the second season). On the other hand, the lowest values recorded in the two seasons were obtained from plants irrigated every 3 days using the highest salt concentration (7500 ppm).

c- Proline content

The data presented in Table (5) show that in most cases, the proline content in the leaves of *Asclepias curassavica* plants was increased steadily with prolonging the irrigation intervals and/or raising the salt concentration. Accordingly, plants irrigated at the shortest intervals (3 days) had the lowest mean proline content (7.9 and 7.1 μ moles/g fresh matter in the first and second seasons, respectively), while those irrigated at the longest intervals (12 days) had the highest mean proline contents (30.5 and 25.8 μ moles/g fresh matter in the two seasons, respectively), regardless of the salt concentration. The increase in the proline content of plants irrigated at long intervals is in agreement with the findings of **El-Khateeb *et al* (1991)** on *Schinus molle*, and **Rober and Horn (1993)**, who reported that the free proline content of *Euphorbia pulcherrima* plants increased with increasing drought stress, and this confirms the role of proline as an indicator of water stress.

Regarding the effect of irrigation water salinity, the data in Table (5) show that plants irrigated with tap water had the lowest mean proline contents (6.4 and 6.0 μ moles/g fresh matter in the two seasons, respectively), while those receiving the highest salt concentration (7500 ppm) gave the highest mean values (34.9 and 31.1 μ moles/g fresh matter in the two seasons, respectively), regardless of the irrigation intervals. Similar results were reported by **El-Khateeb (1994)** on *Murraya exotica*. 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.

Combining the longest irrigation intervals (12 days) with the highest salt concentration (7500 ppm) gave proline contents which were more than twenty times higher than that found in plants irrigated at the shortest intervals (3 days) using tap water (control).

d- Contents of Na, Cl and Ca

The results presented in Table (6) show that in general, the mean contents of Na, Cl and Ca in leaves of *Asclepias curassavica* plants were reduced steadily with prolonging the irrigation intervals (in both seasons). Accordingly, the highest contents of the three nutrients were found in plants irrigated at the shortest intervals (3 days), while the lowest values were obtained from plants irrigated at the longest intervals (12 days). Similar decreases in the Na and Ca contents in leaves of *Schinus molle* have been reported by **El-Khateeb *et al* (1991)** as a result of extending the irrigation intervals. The adverse effect of long irrigation intervals on the accumulation of the three nutrients can be explained by the increase in the concentration of the soil solution that occurs as a result of the dryness of the soil. This increase in the concentration of the soil solution reduces the ability of the roots to perform their function of absorption and translocation of nutrients into the plant. Moreover, the water shortage in the soil (caused by long irrigation intervals) results in a decrease of the absorption rate of minerals by the plant roots. Also, with long irrigation intervals, the quantity of salts that are added to the soil is reduced, compared to the quantity of salts added with frequent irrigation (since the salts are dissolved in the irrigation water). As a result, the amount of the three nutrients available in the soil is much lower with long irrigation intervals than with short irrigation intervals.

The results in Table (6) also show that the Na, Cl and Ca contents were increased steadily with raising the salt concentration. 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 (regardless of the irrigation intervals). This increase in the Na, Cl and Ca 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, Cl and Ca contents with increasing the salinity level have been reported by **El-Mahrouk *et al* (1992)** on *Dodonaea viscosa*, **El-Khateeb (1994)** on *Murraya exotica*, and **Farahat *et al*** (1995) on *Acalypha macrophylla*.

The interaction between the effects of irrigation intervals and salt concentrations also resulted in considerable variations in the Na, Cl and Ca contents in leaves of *Asclepias curassavica* plants. In general, the contents of Na, Cl and Ca were increased by frequent irrigation using high salinity levels. Accordingly, the highest values recorded in both seasons were obtained in plants irrigated at the shortest

Table (6): Effect of irrigation intervals and salt concentrations on the Na, Cl and Ca contents in leaves of *Asclepius curassavica* plants during the 2000/2001 and 2001/2002 seasons.

Irrigation intervals (I)	First season (2000/2001) Salt concentrations (S), ppm							Second season(2001/2002) Salt concentrations (S), ppm						
	Control	1500	3000	4500	6000	7500	**Means**	Control	1500	3000	4500	6000	7500	**Means**
							Na content (% dry matter)							
3 days	0.26	0.47	0.63	0.70	0.78	0.91	**0.63**	0.21	0.45	0.56	0.63	0.70	0.94	**0.58**
6 days	0.23	0.41	0.56	0.61	0.73	0.83	**0.56**	0.20	0.40	0.43	0.55	0.70	0.90	**0.53**
9 days	0.22	0.40	0.49	0.56	0.72	0.78	**0.53**	0.20	0.36	0.38	0.54	0.55	0.76	**0.47**
12 days	0.22	0.40	0.46	0.48	0.68	0.75	**0.50**	0.18	0.28	0.34	0.38	0.43	0.57	**0.36**
Means	**0.23**	**0.42**	**0.54**	**0.59**	**0.73**	**0.82**	---	**0.20**	**0.37**	**0.43**	**0.53**	**0.60**	**0.79**	---
							Cl content (% dry matter)							
3 days	0.46	0.59	0.64	0.78	0.83	0.93	**0.71**	0.40	0.55	0.58	0.75	0.83	0.89	**0.67**
6 days	0.45	0.54	0.59	0.70	0.76	0.90	**0.66**	0.34	0.47	0.56	0.60	0.70	0.80	**0.58**
9 days	0.38	0.50	0.56	0.63	0.68	0.79	**0.59**	0.30	0.40	0.55	0.58	0.65	0.70	**0.53**
12 days	0.35	0.48	0.51	0.59	0.62	0.74	**0.55**	0.19	0.28	0.45	0.50	0.60	0.62	**0.44**
Means	**0.41**	**0.53**	**0.58**	**0.68**	**0.72**	**0.84**	---	**0.31**	**0.43**	**0.54**	**0.61**	**0.70**	**0.75**	---
							Ca content (% dry matter)							
3 days	0.48	0.71	0.82	0.89	0.96	1.30	**0.86**	0.35	0.51	0.68	0.85	0.94	1.00	**0.72**
6 days	0.47	0.54	0.72	0.74	0.86	1.10	**0.74**	0.29	0.51	0.61	0.80	0.85	0.94	**0.67**
9 days	0.41	0.53	0.62	0.63	0.74	1.05	**0.66**	0.25	0.45	0.55	0.79	0.81	0.85	**0.62**
12 days	0.37	0.50	0.58	0.62	0.65	0.81	**0.59**	0.25	0.39	0.44	0.58	0.70	0.73	**0.52**
Means	**0.43**	**0.57**	**0.69**	**0.72**	**0.80**	**1.07**	---	**0.29**	**0.47**	**0.57**	**0.76**	**0.83**	**0.88**	---

intervals (3 days) using the highest salt concentration (7500 ppm). On the other hand, prolonging the irrigation intervals and/or lowering the salt concentration decreased the contents of the three elements, with plants irrigated every 12 days using tap water giving the lowest values.

Conclusion: From the above results, it can be concluded that *Asclepias curassavica* plants can be grown with irrigation every 6 days using tap water, or every 3 days using water with salt concentrations of up to 1500 ppm, with no significant reduction in growth.

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مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٤٨ ، ع(١)، ٣٠٧-٣٢٧ ، ٢٠٠٣

تأثير فترات الرى و تركيز الملوحة على النمو و التركيب الكيميائى لنباتات الـ *Asclepias curassavica* L.

[٢٣]

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أجرى هذا البحث فى مشتل التجارب بقسم بساتين الزينة، كلية الزراعة، جامعة القاهرة، خلال الموسمين المتتاليين ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢. و إستهدف البحث دراسة إستجابة نباتات الـ *Asclepias curassavica* لفترات الرى المختلفة، ولملوحة ماء الرى. تم رى النباتات (وصولاً إلى ١٠٠% من السعة الحقلية) كل ٣، ٦، ٩ أو ١٢ يوم بإستخدام ماء الصنبور (كنترول، ٢٧٠ جزء فى المليون)، أو ماء يحتوى على خليط من أملاح كلوريد الصوديوم و كلوريد الكالسيوم (١:١ وزناً) بتركيزات ١٥٠٠، ٣٠٠٠، ٤٥٠٠، ٦٠٠٠ أو ٧٥٠٠ جزء فى المليون. واشتملت النتائج المسجلة على النسبة المئوية للبقاء، ارتفاع النبات، قطر الساق، و كذلك الأوزان الطازجة و الجافة للأوراق والسيقان و الجذور/نبات. كما أجرى تقدير محتوى الأوراق من الكلوروفيلات الكلية، الكربوهيدرات الكلية، البرولين، الصوديوم، الكلورين و الكالسيوم. ويمكن تلخيص أهم النتائج كما يلى:

- إطالة فترات الرى إلى ٩ أو ١٢ يوم أدت إلى إنخفاض معنوى فى نسبة البقاء وكل صفات النمو الخضرى، مقارنة بالرى كل ٣ أيام.
- تركيزات الملوحة من ٤٥٠٠ حتى ٧٥٠٠ جزء فى المليون أدت إلى إنخفاض معنوى فى نسبة البقاء، بينما التركيزات من ٣٠٠٠ حتى ٧٥٠٠ جزء فى المليون أدت إلى إنخفاض معنوى فى معظم قياسات النمو الخضرى المدروسة مقارنة بالكنترول.
- إطالة فترات الرى مع زيادة تركيز الملوحة فى ماء الرى أدت إلى إنخفاض القيم المسجلة لصفات النمو الخضرى، إلا أنه لم يتم تسجيل أى إنخفاض معنوى فى معظم صفات النمو عند رى النباتات كل ٣ أيام بإستخدام تركيز ملوحة ١٥٠٠ جزء فى المليون، أو كل ٦ أيام بإستخدام

ماء الصنبور، مقارنة بالنباتات التى تـــم ريها كل ٣ أيام بماء الصنبور.

- بصفة عامة أدت إطالة فترات الرى و/أو زيادة تركيز الملوحـــــة إلـــى إنخفـــاض طـــردى فـــى محتـــوى الأوراق مـــــن الكلوروفيلات الكلية، و زيادة محتواهـــــا من البرولين. هـــذا و قـــد زاد محتـــوى الكربوهيدرات الكلية طرديا بإطالة فترات الرى، إلا أنه إنخفض طرديا بالرى بمـــاء يحتوى على تركـــــيزات مرتفعـــة مـــن الملوحـــة (٣٠٠٠-٧٥٠٠ جـــزء فـــــى المليون) مقارنـــة بـــالكنترول. أنخفـــض محتـــوى الأوراق مـــــن الصوديـــــوم والكلورين والكالســـيوم طرديـــا بإطالـــة فترات الرى، بينما زاد بزيـــــادة تركـــيز الملوحة.

من النتائج السابقة يتضح أنه يمكـــن رى نباتـــــات الـــ *Asclepias curassavica* كـــل ٦ أيام بماء الصنبور، أو كل ٣ أيـــام بمـــاء مالح حتى تركيز ١٥٠٠ جزء فى المليـــون، و ذلك دون حدوث إنخفاض معنـــوى فـــى النمو.

تحكيم: أ.د شفيـــق أحمـــد الجنـــــدى

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