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PHYSIOLOGICAL STUDIES ON JOJOBA PLANTS B-EFFECT OF SOME ECOLOGY STRESS ON JOJOBA SEEDLINGS

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ABSTRACT

The present study was carried out in the nursery of Horticulture Research Institute at Giza, Egypt on the seedlings of jojoba (*Simmondsia chinensis*' Link ' Schneider) during two successive seasons (2002 and 2003) to investigate the effect of different available water regimes (A.W.) (100%, 60%, 45%, 30% and 15% of available soil water) and salt concentration levels (5000, 7000, 10000 and 12000 mg/l) on jojoba seedlings. It is obvious that both vegetative growth (stem length, number of shoots and leaves, and leaf area) and root growth (root length, number of roots and root thickness) were significantly increased as A.W. increased in both seasons (2002 &2003). As for dry weight the depletion of the available water decreased leaf, stem and root dry weights with different diameters < 0.2, 0.2 - 0.3 or > 0.3 cm. Meanwhile, photosynthetic pigments and leaf succulence grade were reduced as available water decreased. On the other hand, proline and total sugars increased. As for jojoba NPK leaf nutrient contents nitrogen and potassium were decreased as available soil water of irrigation increased, however phosphorus increased. Salt stress reduced significantly the same aforementioned characters of plant growth and dry weight.The hazard effect was increased as salt concentrations increased whereas, jojoba seedlings irrigated with 12000 mg/l salt concentration has the extremist reduction in growth compared to the control and other lower concentrations. Leaf chlorophyll A, B and carotene besides, leaf succulence were reduced significantly in jojoba plants grown under salt stress during 2002 & 2003. On the contrary, leaf proline content and total soluble sugars were increased. The lower concentrations 5000 and 7000 mg/l has a slight effect on growth and chemical constituent of jojoba seedlings. From these results we can recommend during the early stages of jojoba plant growth in the nursery 100% of available soil water and using water with lowest salt concentration for irrigation as we can, because jojoba is very sensitive in the early stages of growth.

Key words *: chlouphyll, drought, ecology, growth , jojaba , minerals , proline , salinity.*

1. INTRODUCTION

Jojoba plant (*Simmondsia chinensis* Link' Schneider) which is pronounced as ho-ho-ba, belongs to the family Buxaceae. This plant is native to the arid zones of USA and Mexico. Its natural distribution falls between latitudes 25 and 34 in an area which closely approximates the Sonorant Desert (Gentry, 1958). Jojoba plants have currently received a special attention since its seeds contain a valuable liquid wax called jojoba oil. This oil is very similar to that obtained from sperm whale. The liquid wax of jojoba is used as a natural base for wide range of cosmetics and medicinal products, has a heat resistant lubricating properties and useful in chemical industry (Naqvi *et al*., 1988; Wisniak, 1987) besides, it contains about seven essential amino acids and about ten nonessential ones. Jojoba plant is an evergreen, diocious and woody long- lived desert shrub. It can tolerate extreme temperature (35-40°c). It can grow well on 500 Mm/year of rainfall even 100 mm but produces light crop moreover, its salt tolerance extends up to 7000 mg/l (Yermanos, 1979). However, some jojoba lines apparently do not survive salt stress because leaf damage and retarded growth. Besides, it was observed that jojoba is somewhat salt sensitive at the early stages (Kayani, *et al.*, 1990). The type of salt appears to be more significant than the amount. High sodium adsorption ratio (SAR) should be avoided or need to be carefully managed. Further, long-term tolerance to salinity in plantations has not been demonstrated (Wisniak, 1985). This plant can grow well under the arid area. Meanwhile, water regime and salt tolerance, as well as most other cultural practices of this plant have not been investigated under the Egyptian conditions yet. Land reclamation projects in Egypt occupy a very important sector in agricultural development programs; needs crops which tolerate water and salt stress. Therefore, we propose this work to investigate the response of jojoba seedlings to water regimes and different salt concentrations with SAR.

2.MATERIALS AND METHODS

The present study was carried out in the nursery of the Horticulture Research Institute at Giza, Egypt on the seedlings of jojoba (*Simmondsia chinensis* 'Link' Schneider) during two successive seasons (2002 and 2003) to investigate the effect of different available water and salt concentration levels on jojoba seedlings.

2.1. Experiment (1): Effect of different available water levels

Hundred uniform and healthy jojoba seedlings (one year old) were chosen for this study. Both seasons of the experiments started at the beginning of June by transplanting individual seedling into pots of 25 cm in diameter, filled with 7 kg of sandy loam soil taken from the surface layer at the depth of 0 – 30 cm from Ismailia Governorate. Physical and chemical analysis as well as holding properties of the soil were done according to Jackson (1967) and presented in Table, 1(a & b).

Table (1- a): Soil physical properties.

Saturation %	Partial size distribution%			Textural class	$F.C^X$	$W.P^Y$
	Sand	Silt	Clay			
20%	69.7	25.3	5	Sandy loam	16%	3%

FC^X = Field capacity. $W.P^Y$ = Wilting percentage

Table (1- b) : Soil chemical properties.

E.C[Z]	PH	Soluble cations (meq/l.)				Soluble anions (meq/l.)				$CaCO_3$
		Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	CO_3^-	Cl^-	SO_4^-	
1.35	8.26	26.75	2.20	43.90	12.60	9.0	-	43.60	32.85	2.17

EC[Z] = Electrical Conductivity (m mohs/cm).

After transplanting, irrigation was applied to supply the seedling with 100% available water, at two day intervals till the beginning of June during which different treatments were applied. In this experiment, treatments were applied for five months from the beginning of June to the first of November. Five gradient levels of available water were used in this concern to determine the drought tolerance of jojoba seedlings through their influence on growth parameters, physiological activities and chemical constituents of the seedlings. The different levels of available water (AW) used in this experiment were as follows 100%, 60%, 45% 30% and 15% of the available water. Each of the previous water levels was applied to 20 seedlings divided to 5 replicates, each replicate comprised of 4 plants.

2.1.1. Amount of irrigation water

The level of available water was adjusted using the following equation:

Amount of available water = (soil field capacity percentage-soil wilting point percentage)* soil dry weight (Kg).

100% of AW = (0.16 - 0.03)* 7= 0.910 liter = 60% of AW = 0.546 L.; 45% of AW= 0.410; 30% of AW= 0.273; 15% of AW = 0.137 L.

For estimating soil moisture, a scale was used to weigh a pot from each treatment before and after irrigation to develop actually the estimated soil moisture present at which we can irrigate.

* Field capacity was determined in the laboratory by the pressure cooker method at 1/3 atmosphere as outlined by Israelsen and Hansen (1962).

*Wilting point was determined by using the method described by Furr and Reave (1945).

2.1.2.The time of irrigation

In all irrigation treatments, the irrigation started when the water level in the soil reached nearly the wilting point. The amounts of water added were estimated on the bases of soil dry weight to increase the water content to 15%, 30%. 45%, 60% and 100% of AW of the experimental soil.

the study was terminated on the beginning of November during both seasons of the study (2002 & 2003), the following measurements and determinations were recorded.

2.1.3. Growth measurements

By the end of September of each season, growth measurements were recorded as follows:-

- Main stem length (cm). Average number of shoots /plant. Number of leaves /plant and leaf dry weight. Average leaf area (cm^2) using Laser area meter CI-203 (The 4^{th} and 5^{th} leaves from the top of the shoot).and Stem diameter 5 cm above soil level.

Furthermore, at the beginning of November (the end of the growing season) the seedlings were gently removed from the soil, washed under tap water, then shoot and root growth were measured as follow:- shoot length, number of leaves/plant, number of shoots/plant leaf area, main root length (cm), number of root branches and root thickness(cm).

-Plants were divided into three parts (leaves, stems & roots), in the same time every root was divided according to the root diameter into three categories (< 0.2, 0.2 - 0.3 and > 0.3 cm, then oven dried at 70°C till constant weight to measure the dry weight (gm) of the three plant parts.

2. 1.4. Leaf Physiological Properties

2.1. 4.1. Photosynthetic pigments

At the end of September, chlorophyll A,B and carotene pigments were determined (in leaf number 4 & 5 from the terminal bud) according to Brongham, (1960).

2.1.4.2. Leaf succulence grade (L.S.G)

Calculated as the following equation:-

(Fresh weight-dry weight)/Leaf area (cm^2)=(g/cm^2)(Mohamed, 1993).

2.1.5. Chemical constituent

2.1.5.1. Mineral content

At the first week of September of each season, leaf samples were taken from the third to the fifth nodal from the base, then washed , air dried at 70°C till the constant weight, ground and digested according to Chapman and Pratt (1961).

Nitrogen was determined by the MicroKjeldahl method (Pregl, 1945). Phosphorous was estimated by the method of Murphy and Riely (1962). Potassium was determined by flame-photometer according to Brown and Lilleland (1946).Calcium and magnesium were determined by titration against versenate solution (Na-EDTA) (Chapman and Pratt, 1961).

2.1.5.2. Proline content

Proline content was determined in fresh leaves according to the method described by Bates *et al.*, (1973).

2.1.5.3. Total soluble sugars

Total soluble sugars were determined colorimetrically in samples of 0.5 gm, leaf dry matter, according to the method described by Dubios *et al.*, (1956). The amount of estimated sugars in each sample was calculated in term of glucose.

2.2.Experiment(2):The effect of different salt concentration levels

In this experiment 75 uniform one -year old jojoba seedlings were planted in early February during 2002 and 2003 growing seasons in pots (No. 30) containing clay sandy soil in a ratio of 1 : 1 by volume and irrigated with tap water till the end of May. Then, plants were arranged in a randomized complete block design and irrigated with four saline solutions twice weekly and leached with tap water at the fourth irrigation to prevent salt accumulation, then reirrigeted with salt solution in the following day and the control was irrigated with tap water. Salt concentrations were 5000, 7000, 10000 and 12000 mgL^{-1} derived from mixing stock solutions of $CaCl_2$ (2M), NaCl (4M), Kcl (1M), K_2SO_4 (1M), $Na_2 SO_4$ (1M) and Mg So_4 (1M). One liter of different solutions was prepared as ml/l as shown in Table (1 -c). This yields a millequivalent ratio of about 1Cl:1 SO_4 and sodium adsorption ratio (SAR) of 12. SAR= $Na^+/\sqrt{(Ca^{2+}+ Mg^{2+})/2}$.

Irrigation with salt solutions started at the end of May and extended until the end of November.

Table (1 -c):Diluted solutiens as (ml/l) prepared from different stock solutions as molar per one liter of water added to irrigate jojoba plants during 2002 and 2003 groing seasons.

salt conc. (mgL^{-1})	Ca Cl_2 ml/L	$MgSO_4$ ml/L	Kcl ml/L	K_2 SO_4 ml/L	Na_2 SO_4 ml/L	Na Cl ml/L
5000	3.828	4.225	1.757	1.224	10.565	5.128
7000	4.773	10.250	4.730	5.455	11.340	7.693
10000	7.883	18.300	7.838	7.745	14.575	10.258
12000	11.263	10.000	4.030	10.34	15.495	11.965

2.2.1. Growth measurements

The plants were carefully pulled from the pots at the end of November and washed under tap water, divided into roots, stems and leaves, then air dried for measurements as mentioned in the experiment (1).

2.2.2. Chemical analysis

Measurements *e.g* photosynthetic pigments, Leaf succulence grade (L.S.G)., mineral, proline and total soluble sugars as described before.

Statistical analysis

All experiments in this study followed a complete randomized design in a factorial experiment. The data were subjected to analysis of variance (ANOVA) according to Snedecor and Cochran (1980). Differences between treatments were compared by Duncans multiple rang test described in the SAS(SAS,1986).

3.RESULTS AND DISCUSSION

3.1. Effect of different water levels on jojoba plants

3.1.1.Plant growth

3.1.1.1. Shoot and root growth

Effect of water regimes 100%, 60%, 45%, 30% and 15% of available soil water (A.W) on the vegetative and root growth of jojoba seedlings is shown in Table, (2). It is obvious that both the vegetative growth (stem length, number of shoots/plant and No. leaves/plant, and leaf area) and root growth (root length, number of roots and root thickness) were significantly increased as A.W.

increased in both seasons (2002 &2003). The highest values of the the vegetative and root growth were obtained with the plants irrigated with 100% A.W.. On the contrary, 15% of A.W. gave the lowest values in both seasons. Whereas, 60%, 45%, 30% of A.W treatments were arranged in a descending order. Concerning plant growth, it can be concluded that the vegetative and root growth have decreased under water stress conditions. This may be due to the translocation of abscisic acid from leaves to stem to induce depression of longitudinal growth of shoots(During, 1979).

Generally, the reduction in plant growth under water stress was previously reported by Michelakis and Vougiukalouv,(1988), Metheny *et al.*, (1994), Ali, (1998) on different olive cultivars and Abou Taleb (1998) on pomegranate. The dwarfism of plants under low available water stress may be due to the relatively severe reduction pertaining to plant tissues, cell size, number of cells per unit or intercellular space (El-Beltagy *et al.*, 1984). The depression of shoot growth may possibly be direct adaptation to high water stress.

3.1.1.2. Plant dry weight

Data presented in Table, (3) show that during 2002 and 2003 growing seasons, dry weights of different plant organs (stem, leaves and dry weights of different root parts, < 0.2, 0.2-0.3 and > 0.3 cm) were decreased under water stress. The great loss in dry weight was noticed in the low concentrations of available water 15%, 30% followed by 45% and 60% A.W. treatments. There was no significance between 15% and 30% treatments or 45% and 60% A.W. treatments. The unfavorable effect of drought on the dry weight of plant organs may be due to the loss of turgidity that affects the rate of cell expansion and ultimate cell size (Hale and Orcutt, 1987). The depressive effect of water stress on dry weight was reported by Badizadagan (1975), Swietlik and Miller (1983) Chartzoulakis and Michelakis (1994) and Abou El-Waffa (2002).

3.1.2. Chlorophyll and leaf succulence grade

The effect of water regime on chlorophyll A, B and caroten besides leaf succulence grade in jojoba seedlings during 2002 and

2003 growing seasons is shown in Table (4). The results revealed that foliar pigments in the plants irrigated with 100% A.W. exhibited the highest values. Then, 60% followed in descending order by 45%, 30% and 15% A.W. in both seasons.

These results are in agreement with El-Said *et al.*, (1993), Adel, (1998) and Abou Taleb *et al.*,(1998) on different olive cvs.

3.1.3. Chemical constituent

3.1.3.1. Proline

Data concerning the accumulation of free proline in the leaves of jojoba seedlings grown under different water regimes are presented in Table, (4). It is clear that poline accumulation was significantly affected by different water regimes. Proline content was significantly increased by decreasing the available soil water. Meantime, the highest and lowest values were obtained from leaves of jojoba plants irrigated with 100% and 15% of the available soil water respectively. These results coincide with Hasegawa *et al.*, (1984); El- Said *et al*, (1993); Abou Taleb *et al.*, (1998) and Abou El-Wafa (2002). Free proline may accumulate in the plant under water stress (Boggess *et al.*, (1976) and proved that the increase in proline is the result of its synthesis and not due to protein degradation.

According to the aforementioned results it may be concluded that jojoba seedlings could resist water stress for a relatively long time. These results go in line with those reported by El-Said *et al.*, (1993) and Ali (1998) on olive seedlings.

3.1.3.2. Total soluble sugar content

In Table (4), the results show that leaf total soluble sugars content decreased significantly by increasing A.W from 15% to 100% in both seasons. However, there was no significant difference between 45% and 30% A.W. treatments. The increase in total soluble sugars under high water stress may be attributed to the increment of amylase (Adel, 1998). Moisture stress may cause a direct loss of water from the tissues and increases hydrolysis of starch, resulting in an increase of sugars (Nomir, 1994). Similar observations were noticed with guava seedlings (El-Hefnawi, 1986; Ahmed, 1990 on fig; and Ali, 1998 on different fruits).

Table (2). Effect of different available soil water levels on plant growth of jojoba seedlings during 2002 & 2003 growing seasons.

Percentage of available water	Stem length (cm)		Number of shoots/plant		Number of leaves/plant		Leaf area (cm^2)		Root length (cm)		Number of roots/ plant		Root thickness (cm)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
100%	58.58a*	49.42a	12.42a	10.17a	45.75a	71.42a	5.60a	6.66a	53.33	60.00a	4.30a	7.30a	1.56a	1.20a
60%	44.08b	38.43b	7.80b	7.18b	32.33b	52.0b	4.20b	4.46b	41.00b	53.00b	3.20b	5.20b	0.96b	0.91b
45%	40.75b	36.33b	6.5b	6.15b	32.0b	50.20b	3.70c	4.20c	40.00b	43.33c	3.00b	4.33b	0.63c	0.63c
30%	36.33b	25.40c	4.10c	4.0c	22.0c	31.0c	3.21d	3.28d	30.00c	41.00d	1.67c	4.00b	0.60c	0.50d
15%	20.30c	23.5c	3.20c	2.90c	19.5c	28.40c	2.60e	2.80e	24.00d	38.33e	1.33c	2.55c	0.53c	0.43d

Table (3): Effect of different available soil water levels on plant dry weight of jojoba seedlings during 2002 & 2003 growing seasons.

Percentage of available water	Dry weight (gm)									
	Leaves		Stem		Root (< 0.2 cm diameter)		Root (0.2-0.3cm diameter)		Root (> 0.3 cm diameter)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
100%	6.55a*	4.50a	7.00a	4.95a	3.22a	4.50a	5.40a	4.32a	7.63a	7.98a
60%	4.10b	3.00b	4.50b	3.33b	2.00b	2.70b	4.00b	3.00b	5.40b	5.30b
45%	3.60bc	2.23bc	3.20bc	2.50bc	1.95b	2.50b	3.20b	2.60b	5.22b	4.90bc
30%	2.50c	1.80c	3.00c	1.98c	1.78b	1.30c	2.10c	2.20bc	3.60bc	2.63c
15%	1.80c	1.66c	2.06c	1.63c	1.03c	1.10c	1.56c	1.50c	2.72c	2.20c

Table (4): Effect of different available soil water levels on Chlorophyll (A&B) and caroten (mg/g F.W.), proline, total soluble sugars and leaf succulence grade of jojoba seedlings during 2002 & 2003 growing seasons.

Percentage of available water	Chlorophyll (A)		Chlorophyll (B)		Caroten		Proline (g/100g F.W.)		Total soluble sugars (mg/g)		Leaf succulence grade (g/cm^2)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
100%	0.90a*	0.85a	0.70a	0.73a	0.55a	0.57a	0.06d	0.07c	0.015d	0.016d	1.49a	1.78a
60%	0.70b	0.65b	0.51b	0.55b	0.42b	0.45b	0.12c	0.11c	0.023bc	0.021c	0.85c	1.30b
45%	0.65bc	0.54c	0.45c	0.49b	0.36c	0.40b	0.18b	0.16b	0.028b	0.026b	0.92b	1.18c
30%	0.60c	0.50c	0.40cd	0.40c	0.32d	0.30c	0.19b	0.17b	0.029b	0.027b	0.70d	1.16c
15%	0.41d	0.37d	0.36d	0.32d	0.30e	0.26c	0.34a	0.36a	0.035a	0.033a	0.57e	0.64d

*Means followed by the same lower case letter within the same column are not significantly different, p = 0.05.

3. 1.3.3. Leaf NPK nutrient content

The effects of irrigation with 100%, 60%, 45%, 30% and 15% of A.W. on jojoba seedlings leaf nutrient content (NPK) are presented in Table (5). Data indicated that, as A.W. increased the leaf nitrogen and potassium content were decreased. On the contrary, the leaf phosphorus content was increased. These results are similar to that reported by Ahmed (1990) on fig, Adel (1998) on olive. The increase in leaf nitrogen content may be due to the increase of metabolic compounds that contain nitrogen such as amino acids and the low consumption of such compounds in the sink as a result of the restricted growth of the plant. The reduction of phosphorus in jojoba leaf content depending upon binding of their salts in the soil or decreased soil conductivity or may be due to the die back of the absorbing root under drought conditions(Vaadia *et al.*, 1961).

Table (5): Effect of different available soil water levels on leaf N,P&K contents of jojoba seedlings during 2002 & 2003 growing seasons.

Percentage of available water	N%		P%		K%	
	2002	2003	2002	2003	2002	2003
100%	1.36e[x]	1.73e	0.35a	1.94a	0.06d	0.07c
60%	1.85d	2.05d	0.25b	143b	0.12c	0.11c
45%	2.34c	2.55c	0.20bc	1.22c	0.18b	0.16b
30%	2.65b	2.77b	0.17cd	1.13d	0.19b	0.17b
15%	2.94a	3.01a	0.13d	0.88e	0.34a	0.36a

[x]Means followed by the same lower case letter within the same column are not significantly different , $p = 0.05$.

3.2. Effect of different salt concentration levels with SAR (12) on jojoba seedlings

3.2.1. Plant growth

3.2.1.1. Shoot and root growth

It is obvious from Table (6) that the vegetative growth represented by stem length, number of shoots/plant and leaf area and root growth represented by root length, number of roots and thickness were negatively affected with salt stress. The hazard effect was increased as salt concentrations increased. Jojoba seedlings irrigated with 12000 mgL salt concentration had the extremist reduction in growth compared to the control and other lower concentrations. The decline in leaf growth is the earliest response of glycophytes exposed to salt stress (Munns and Termaat, 1986). These results coincide with Burgos, *et al.*, (1993) and Benzioni *et al.*, (1996) on jojoba and Gaser (1992), Bartolini *et al.*, (1991), Tattini *et al.*, (1999); Atta. (2002) and Maklad, (2003) on fruit crops. The adverse effect of salinity on plant growth may be due to the increase of osmotic potential of the soil resulting in a reduction of the available water, besides the toxic effect of some ions causing disturbance in the normal metabolism of the plants (Bernestein, 1975).

3.2.1.2. Plant dry weight

The effect of salt concentrations 5000, 7000, 10000 & 12000 mgL^{-1} (SAR 12) on jojoba seedlings dry weight is presented in Table, (7). These results show that salt concentrations had a significant depressive effect on shoots, leaves and root dry weights (< 0.2, 0.2 - 0.3 & > 0.3 cm in diameter) compared to the control. Meantime, as salt concentration increased, the aforementioned characters of the plant dry weight were reduced and the highest adverse effect was clear on the plants irrigated with 12000 mgL^{-1}. However, there was no significant difference between 7000 & 5000 mgL^{-1} or 12000 &10000 mgL^{-1} except the roots of 0.2 - 0.3 cm in diameter dry weight. There was a significant difference between aforementioned lower and higher concentrations in the first season (2002) only. These results go in line with Khamis *et al.*, (1984), Abou El-Khashab (1991&1997) and Abd El-Maksoud *et al.*, (1995).

3.2.2. Leaf physiological properties

3.2.2.1. Photosynthetic pigments and leaf succulence grade

Table (8) reveals that leaf chlorophyll A, B and caroten besides, leaf succulence in jojoba plants grown under salt stress were reduced significantly during 2002 & 2003 except leaf succulence during 2002 growing season it did not take definite trend.The reduction was clear in the plants irrigated with 10000 & 12000 mgL^{-1} than 5000 & 7000 mgL^{-1}. Although, there was no significant difference between 5000 and 7000 mgL^{-1} in chlorophyll A or B, there was a significant difference between them in caroten content. These results are in agreement with those of Gaser (1992) and El-Sayed *et al.*,(1995). The reduction in chlorophyll content of salinized plants had been studied by Jackson and Ortli (1956) who suggested that the depressive effect of salinity on the absorption of ions e.g iron was involved in chloroplast formation via protein synthesis or the depression of chlorophyll as a result of ammonium accumulation in plant leaves through the breakdown of plastides (Puritch and Parker, 1967).

3.2.3. Leaf chemical constituents

3.2.3.1. Proline and total soluble sugars

As for proline and total sugar content, they were increased significantly in both growing seasons 2002 & 2003 as salt concentrations in irrigation water were increased. The accumulation of proline and total sugars were maximized in leaves of the plants irrigated with 12000 mg/l. These results are consistent with Kayani *et al.*, (1990) on jojoba seedlings and El-Sayed *et al.*, (1995) and Atta (2002) and Maklad, (2003) on olive. Proline content increased proportionally in plants under salinity stress faster than the other amino acids and has been suggested as an evaluation parameter for selecting resistant varieties (Bates *et al.*, 1973). The increase in total soluble sugar content under stress may be attributed to the increment of amylase activity (Henckel, 1964) or due to the hydrolysis of starch, resulting in an increase of sugar concentration (Nomir, 1994).

3.2.3.2. Leaf mineral content

It is evident from Table (9) that different salt concentrations (5000, 7000, 10000 and 12000 mgL^{-1}) decreased jojoba leaf N, P and K contents. On the contrary, Ca and Na contents were increased as salinity increased. However, Mg content did not have any definite trend. These results are consistent with Burgos *et al.*, (1993) and Behairy *et al.*, (1985); Bartolini *et al.*, (1991); El- Sayed *et al.*, (1995), Atta (2002); Chartzoulakis, *et al.*, 2002) and Maklad (2003) on olive trees.

Abou El-Khashab (1997) on olive and peach seedlings concluded that high reduction in plant growth under salinity was possibly due to the accumulation of Na in plant tissues in toxic amounts and causing leaf injury symptoms. Besides the reduction in K content may be attributed to the increase in Na uptake resulting in cationic imbalance in the plant.

Table (6): Effect of different salt concentrations (SAR 12) on plant growth of Jojoba seedlings during 2002 & 2003 growing seasons.

Salt concentrations (ppm)	Stem length (cm)		Number of shoots/plant		Number of leaves/plant		Leaf area (cm^2)		Root length (cm)		Number of roots/plant		Root thickness (cm)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	60.56a[z]	55.40a	13.30a	12.00a	56.30a	63.40a	5.90a	5.73a	57.33a[z]	65.00a	10.00a	9.00a	0.90a	0.75a
5000	45.30b	41.50b	7.50b	8.00b	35.20b	40.00b	4.60b	4.50b	50.00b	50.00b	7.00b	7.00b	0.73b	0.50b
7000	42.33b	39.00b	5.90bc	7.20b	30.33b	32.20c	3.20c	3.33c	48.67b	50.00b	7.00b	6.20b	0.73b	0.47b
10000	30.22c	28.20c	4.40cd	4.00cd	21.50c	20.00d	2.70d	3.23c	41.67c	40.00c	5.20c	4.50c	0.72b	0.43b
12000	26.50c	25.00c	3.00d	2.50d	16.00c	17.00d	2.60d	2.20d	35.00d	36.00d	3.40d	3.00d	0.57c	0.30c

Table (7). Effect of different salt concentrations (SAR 12) on plant dry weight of Jojoba seedlings during 2002 & 2003 growing seasons.

Salt concentrations (ppm)	Dry weight (gm)									
	Leaves		Stem		Root (< 0.2 cm diameter)		Root (0.2-0.3 cm diameter)		Root (> 0.3 cm diameter)	
	2002	2003	2002	2003	2002	2003	2003	2003	2002	2003
Control	5.58a[z]	6.98a	3.33a	4.23a	3.68a	3.69a	3.87a	3.33a	6.72a	6.68a
5000	3.82b	4.92b	2.03b	3.00b	2.42b	2.50b	3.02b	2.03b	5.00b	4.62b
7000	2.98b	3.50b	1.93b	2.48b	2.41b	2.26b	2.35c	1.94b	4.23bc	3.79bc
10000	1.65c	2.61c	1.59c	2.05bc	1.36c	1.20c	2.09d	0.98c	3.02c	2.90c
12000	1.33c	2.30c	1.39d	1.56c	1.12c	1.04c	1.49e	0.95c	1.86d	1.50d

Table (8): Effect of different salt concentrations (SAR 12) on leaf Chlorophyll (A&B) and caroten (mg/g F.W.), proline, total soluble sugars and leaf succulence grade of Jojoba seedlings during 2002 & 2003 growing seasons.

Salt concentrations (ppm)	Chlorophyll (A)		Chlorophyll (B)		Caroten		Proline (g/ 100g)		Total soluble sugars (mg/g)		Leaf succulence grade (g/cm^2)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	0.58a[z]	0.90a	0.85a	0.72a	0.73a	0.59a	0.11e	0.09d	0.017e	0.015e	1.65b	1.65a
5000	0.60b	0.63b	0.60b	0.52b	0.54b	0.43b	0.20d	0.17d	0.024d	0.021d	1.35c	1.21c
7000	0.56b	0.57b	0.56b	0.50b	0.52c	0.36c	0.28c	0.26c	0.029c	0.027c	1.74a	1.36b
10000	0.44c	0.42c	0.44b	0.42c	0.51cd	0.31cd	0.33b	0.34b	0.040b	0.036b	1.74a	0.99d
12000	0.39d	0.35d	0.39c	0.33d	0.35d	0.28d	0.47a	0.42a	0.052a	0.046a	0.76d	0.54e

[y]Means followed by the same lower case letter within the same column are not significantly different $p = 0.05$

Table (9): Effect of different salt concentrations (SAR 12)on leaf mineral elements of Jojoba seedlings during 2002 &2003 growing seasons.

Salt concentrations (ppm)	N%		P%		K%		Ca%		Mg%		Na%	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	1.64d[z]	2.65e	0.34a	0.33a	1.93a	1.85a	1.91c	1.98c	0.193a	0.220b	0.40e	0.35e
5000	1.86c	1.91d	0.25b	0.24b	1.48b	1.47b	2.05b	2.11ab	0.210a	0.230b	0.65d	0.60d
7000	2.14b	2.26b	0.19c	0.18c	1.30c	1.27c	2.12a	2.08b	0.220a	0.223b	0.85c	0.78c
10000	2.19b	2.50b	0.16cd	1.16cd	1.17d	1.08d	2.12a	2.14a	0.230a	0.290a	0.90b	0.89b
12000	2.85a	2.88a	0.12d	0.12d	0.96e	0.85e	2.11ab	2.13a	0.240a	0.307a	1.17a	1.04a

[y]Means followed by the same lower case letter within the same column are not significantly different , p = 0.05.

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دراسات فسيولوجية على نبات الهوهوبا

ب- تأثير بعض الإجهاد البيئى على شتلات الهوهوبا

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ملخص

تم اجراء هذا البحث في مزرعة معهد بحوث البساتين فى الجيزة على شتلات الهوهوبا في عامى ٢٠٠٢ و ٢٠٠٣ لدراسة تأثير الإجهاد بنقص الماء الميسر ٦٠% و٤٥% و٣٠% و١٥% وزيادة تركيز الأملاح فى مياه الرى ٥٠٠٠ و٧٠٠٠و١٠٠٠٠ و١٢٠٠٠مجم/لترواتضحت النتائج الأتية:

أدى زيادة معدلات الماء الميسر للنبات الى زيادة معنوية في النمو الخضرى ممثلا فى طول الساق وعدد الأفرع وعدد الأوراق والمساحة الورقية وكذلك نمو المجموع الجذرى مثل طول الجذر وعدد الجذور الرئيسية وسمك الجذر الرئيسي.

أدى نقص الماء الميسر الى انخفاض الوزن الجاف للأوراق والسوق وكذلك وزن المجموع الجذرى الجاف مقسماً حسب القطرالى اقل من ٠,٢ سم ومن ٠,٢ –٠,٣ سم وأكثر من ٠,٣ سم. وفى نفس الوقت أدى نقص الماء الميسر الى انخفاض محتوى الأوراق من صبغات الكلوروفيل والكاروتين ، فى حين زاد محتوى الأوراق من البرولين والسكريات الكلية. هذا بالإضافة الى زيادة محتوى الأوراق من النتروجين والبوتاسيوم تحت ظروف نقص المياه فى حين انخفض محتوى الفوسفور فى الأوراق.

أدت زيادة الأملاح الى نقص فى النمو الخضرى والوزن الجاف للنبات ممثلاً فى الصفات المذكورة من قبل للمجموع الخضرى والمجموع الجذرى. ولقد زاد الضرر نتيجة الرى بالأملاح كلما زاد تركيز الأملاح فى مياه الرى. سجلت النباتات التى تم ريها بتركيز ١٢٠٠٠مجم/لتر أعلى انخفاض فى النمو والوزن الجاف مقارنة بالكنترول والتركيزات المنخفضة. وفى نفس الوقت أدت الزيادة فى تركيز الأملاح الى انخفاض محتوى الأوراق من الكلوروفيل ودرجة العصارية فى الأوراق خلال عامى الدراسة، إلا أن محتوى البرولين والسكريات الكلية فى الأوراق قد زاد زيادة معنوية.

ومن هذه النتائج يتضح الأتى :- رغم أن شجيرات الهوهوبا المثمرة تتحمل ظروف البيئة القاسية من الجفاف والملوحة المرتفعة الا أن الشتلات فى مراحل النمو الأولى يجب أن تروى بأعلى معدل من الماء الميسر (١٠٠%) واختيار مصدر رى قليل الأملاح (اقل من ٥٠٠٠ جزء فى المليون) قدر الإمكان حيث أن الشتلات تكون حساسة جداً فى هذه المرحلة من النمو.

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