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# RESPONSES OF JOJOBA SEEDLINGS TO DIFFERENT LEVELS OF SALINITY AND SODIUM ADSORPTION RATIO : IMPLICATION OF FOLIAR PHOSPHORUS NUTRITION FOR SALT TOLERANCE

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## ABSTRACT

Pot experiments were conducted during 2002 and 2003 seasons to study the effect of irrigation water with three salinity levels, 4000 , 6000 and 8000 ppm with two levels of Sodium Adsorption Ratios (SAR) 6 & 12 and foliar sprays of phosphorus as $H_3PO_4$ ; at the highest level of salinity and SAR 6& 12 on plant growth ,some physiological aspects, changes of chemical constituents of jojoba seedlings, as well as the effect on anatomical features of jojoba leaf .

Also, the study aimed to determine the physiological mechanism of phosphorus as foliar application in reducing salt stress effects on jojoba seedlings .

The obtained results could be summarized as follows:

Increasing salt concentration in irrigation water caused marked decrease in growth parameters of both seasons, namely, stem length, number of leaves / plant, leaf area and assimilation area as well as dry weight of leaves ,fresh and dry weight of stem and roots of jojoba seedlings. In contrast, fresh weight of leaves significantly increased, it mainly due to an increase in tissue water content reflected in the increasing fresh weight: dry weight ratio which can take as a good indicator of tissue succulence within plant.

The result also indicated that treating the seedlings which growing under 8000 ppm and SAR 6 &12 by phosphorus foliar sprays apparently tended to minimize the adverse effect of salinity.

No visual salt damage in vegetative growth during the two seasons, where the survival percentage was 100% in all treated plants were observed. It seems that jojoba seedlings able to tolerate the salt concentrations of irrigation water up to 8000 ppm although; vegetative growth was significantly reduced under that salinity treatment.

Regarding the effect of salinity levels in irrigation water on physiological and chemical aspects, the obtained data showed that, leaf osmotic potential (LOP) ,leaf succulence grade (LSG) , total soluble sugars and proline content increased with increasing salinity levels, whereas, results in both seasons showed significant reduction in chlorophyll a , b and carotene content as well as N , P , K content in the leaves of jojoba seedlings compared with control in two seasons.

Sodium and chloride were significantly accumulated in jojoba leaves in response to the increase in salinity levels of irrigation water. The amount of $Na^+$ and $Cl^-$ uptake by jojoba plants appear to be the highest under the highest salinity level comparing with other treated salinity levels in the two seasons.

Phosphorus application significantly increased chlorophyll a, b and carotene, on the other hand P decreased total soluble sugars and proline content in leaves of jojoba seedlings as compared with only irrigated with saline water.

Concerning the effect of phosphorus sprays on minerals content of jojoba leaves, results showed that P treatment results in higher leaf N, P and K content of jojoba seedlings than their analogous without P spraying. Moreover, P application to plants results in a significant reduction in $Na^+$ and $Cl^-$ concentration in leaves of jojoba

seedlings irrigated with saline water at 8000 ppm and SAR 6 &12 as compared with those without P treatment.

Regarding the anatomical structure of leaf microscopic studies should that ,leaf of jojoba consisted on three layers : the epidermis , the mesophyll ( isolateral and organized completely as palisade like tissue and consisted on two regions surrounding a third each region oblong in out line ) and vascular bundles . The data showed significant difference between the treated and untreated sector, leaf blade thickness and axial diameter of leaf midvein increased with increasing salinity levels in irrigation water .The values of mesophyll thickness showed the same trend of leaf thickness under different salinity levels. No significant difference in the thickness of epidermis and cuticle were recorded in leaf of treated and un-treated seedlings .

In conclusion salt tolerance in jojoba related to the ability of the plant to accumulate high concentration of $Na^+$ and $Cl^-$ in leaves without causing visible damage .In addition accumulation of $Na^+$ and $Cl^-$ in jojoba leaves may be indicate the utilization of both ions for osmotic adjustment in vacuoles that improve the water balance .

It should be emphasized that jojoba is considered to be a salt-tolerante plant typical of many halophytes to salinity stress.

## INTRODUCTION

Salinity is a continuing threat to economic crop production in arid and semiarid regions of the world. Millions of hectares of salt-affected soil are wide-spreaded all over arid and semi arid regions throughout the world already exist, and more soils being added each year due to secondray salinization .A search for a plant species with an economic potential as a crop that is already somewhat adapted to saline conditions is a prerequisite for the proper utilization on these salt-affected soil.. Jojoba (*Simmondsia chinensis* [Link] Schneider) is considered to be one of these species ,it is a perennial, evergreen, dioecious, much branched, shrub or shrubby tree native to the Sonoran Desert of the southwestern of United States and northern Mexico (Genty,1958 , Kayani *et al.*, 1990) . Also jojoba is well adapted to drought, soil salinity ,and extreme temperature (Adams et al.,1978).

Jojoba has special interest as a possible commercial crop because the seeds containing about 50% of liquid wax which can be used as a substitute for sperm whale oil that has applications in several industries as a lubricant additive to oils and a cosmetic base (National Research Council. 1985). Since water is the main limiting factor in agriculture, Benzioni *et al.*, (1996), reported that jojoba could be grown and flower on marginal water, mainly sewage, effluent and brackish. In addition, Yermanos *et al.* (1967) did not find any damage to vegetative growth at a salinity of 108 mM (ca.11ds $m^{-1}$),but a serious reduction in the number of flower buds and potential yield was noticed at this level of salinity.

Salt tolerance seems to be related to the ability of Jojoba plants to accumulate and compartment both $Na^+$ and $Cl^-$ at high concentrations in their leaves and to keep salt levels constant for a long period (Benzioni *et al.* 1996).

Salinity treatments decreased the concentration of P in both the soil solution and plant leaves, therefore phosphorus treatment reduced foliar symptoms of salt damage in tomato and nearly doubled the fruit yield ( Awad *et al.*,1990). Phosphorus addition to the saline conditions enabled the maintenance of relatively low levels of $Na^+$ and high levels of $K^+$ in immature leaves .This was in contrast to levels of $Na^+$ and $K^+$ in the order mature leaves . This demonstrated that P addition to saline nutrient solutions may enhance the capacity to regulate ions distribution between leaves of different age. The requirement for more P in salinized plants could be related to its role in energy fixation and carbohydrate partitioning and transport (Gibson 1988 & Bieleski and Ferguson 1983 ).

Moreover, P also involved in the formation of cell membrane lipids, which play avail role in ionic regulation (Bieleski and Ferguson, 1983 ), Moreover, P deficits decreased both stomatal conductance and the hydraulic conductance of roots which increase plant water deficits and inhibit leaf expansion (Radin and Eidenbock, 1984).

Because of the interest in cultivating jojoba in Egypt we undertook seedlings to:-

1- Study the effect of irrigation with different levels of salinity(4000, 6000, and 8000 ppm ) and two levels of Sodium adsorption ratios (SAR) 6 & 12 for each concentration on vegetative growth , physiological aspects and chemical constituents of jojoba seedlings , as well as anatomical features of leaf .

2- Study the effect of phosphorus $H_3PO_4$ (1000 ppm ) as foliar application at the highest level of salinity(8000ppm) with SAR 6 , 12 on growth, and determine the physiological mechanism of phosphorus in reducing salt stress effects of plant.

## MATERIALS AND METHODS

The present study was carried out during 2002 and 2003 seasons in the greenhouse of the experimental orchard of the Horticulture Research Institute, Giza Governorate ,Egypt, to study the effect of irrigation with different levels of saline water and phosphorus application ,at the highest salinity level ; on growth. some physiological aspects, chemical constituents and anatomical features of jojoba seedlings.

Uniform and healthy one-year-old of Jojoba (*Simmondsia chinensis* Link,Schnider) seedlings were transplanted in February in plastic pots of 25 cm in diameter and 30 cm in depth, containing 6 kgs / pot of sandy clay loam soil, free from salts taken from the surface soil layer (0 -30 cm) of Ismaillia Governorate .

Some physical and chemical properties of the used soil in this study were determined by Soil, Water and Environment Res. Inst., Agric. Res. Center, according to the method as described by Jackson (1973) and were summarize in Table ( 1 )

**Table (1) Physical and Chemical properties of the experimented soil**

**(A) Physical properties**

| Saturation Percent | Partial size distribution | | | Textural class | *F.C.** | *W.P.*** |
|---|---|---|---|---|---|---|
| | Total sand | Silt | Clay | | | |
| 20% | 69.7 | 25.3 | 5 | Sand loam | 16% | 3% |

**(B) Chemical properties**

| E.C*** | *PH* | Soluble cations (me/l) | | | | Soluble anions (me/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 | 9.00 | - | 43.60 | 32.85 | 2.17 |

F.C*= Field capacity. W.P**= Wilting Point. E.C***= Electrical Conductivity (m.mhos/cm$^3$).

The plants were irrigated twice a week with tap water before application of saline solution at the first week of May up to late November in both seasons. The plants were irrigated with three levels of salinized water by dissolving Na Cl, Na $SO_4$ , Ca $Cl_2$ , Mg $SO_4$ and $KSO_4$ salts to obtain saline solutions at concentrations 4000, 6000 and 8000 ppm and SAR (sodium adsorption ratio) 6 and 12 , for each saline level ,calculated on the basis of the following equation

$$SAR : \sqrt{\frac{Na}{Ca + Mg/2}}$$

Phosphorus treatment as $H_3PO_4$ (1000 PPM) was added as three foliar applications on 15$^{th}$ May, June, and July to seedlings under irrigated with saline water (8000ppm) with SAR 6&12 during both seasons of study .
The above treatments were arranged in factorial complete randomized design. Each treatment was replicated three time, comprising 9 plants, to receive one of salt treatment, besides that of phosphorus spray.

The untreated (control) plants were irrigated with tap water (400 ppm). Irrigation with saline water was applied twice a week using 750 ml / pot. started in the first week of May and ended at late November in both seasons.

To prevent salt accumulation in soil, salt were leached every 21 days by irrigation with tap water to reach approximately EC (0.29 – 0.31 m. moles), followed by re-watering with the corresponding saline solutions . Control treatment was irrigated by tap water ( 400 ppm ) at the same rate.
Hoagland solution (Hoagland and Arnon, 1950) was added biweekly for all treatments throughout the growth period to avoid salt shock.

At the end of season ( late November ) nine seedlings (representing 3 replicates) of each treatment were carefully pulled from the pots, the roots were washed, air dried and used for the following parameters :

**[ 1 ] Vegetative growth :-**

1- Stem length (cm) and its rate of increase (cm / season).
2-Average number of leaves / plant.
3-Average leaf area (cm$^2$) using Area Meter CI-203.
4-Assimilation area ( cm$^2$/plant) .
5-Fresh and dry weight of different plant organs i.e leaves, stem and root (g).

**[ 2 ] Physiological aspects of leaf:**

**1- Leaf osmotic potential (LOP) :**

Total soluble solids (TSS) was determined in the sap of leaf samples by a refractometer and equivalent values of the osmotic potential were estimated according to Gusov (1960).

**2- Leaf succulence grade (LSG)**

$$LSG = \frac{\text{leaf fresh W} - \text{leaf dry W}}{\text{Leaf area(dec)}^2}$$

**=g water content / dec$^2$ of leaf area, as described by Poljakoff (1975).**

**[ 3 ] - Chemical constituents :**

**1- Foliar pigment contents :-**

The quantitative analysis of photosynthetic pigments (mg / g. F.W.) was determined in samples of sufficient fresh leaves. The optical densities were measured colorimetrically at 662 , 644 and 440 µ.M wave length for chlorophyll (a) , (b) and carotene respectively according to Saric *et al.,* (1967).

**2-Total soluble sugars :-**

Total soluble sugars ( mg/g D.W.) were determined colorimetrically in leaf dry matter according to method of Dubois *et al.*, (1956)

**3- Leaf proline content:**

The proline content ( g /100g F.W.) was determined in fresh leaves according to the method described by Bates *et al.*, (1973).

**4- Leaf mineral contents:-**

Samples of fully expanded mature leaves presented at the third node from plant top were taken and dried at 70° C till constant weight then ground and used for subsequent determination of N,P,K,Na and Cl in each sample as follows:

a) Nitrogen was determined by the modified micro-kjeldahl method as described by Pregl (1945)
b) Phosphorus was determined colorimetrically according to A.O.A.C (2000)
c) Potassium and Sodium were determined by atomic emission analysis according to A.O.A.C (2000).
d) Chloride was extracted from ash samples with hot water titrated with standard silver nitrate solution and then determined according to A.O.A C (2000).

**[ 4 ]Anatomical studies:**

Fresh samples of mature leaves were taken at the end of the experimental period, cleaned from dust and immediately killed and fixed in formalin-acetic acid- alcohol ( FAA) solution. Then, dehydrated with N-butanol and paraffin wax (56-58° C) for infiltration and embedding . Serial transverse sections of 10 micron thickness were prepared using a rotary microtome. Saffranin and fast green stains technique were followed, then the cross sections washed in absolute ethanol and cleared in xylol and mounted in Canada balsam (Johnson 1940).

Depth of epidermal cell, the thickness of leaf blade, axial diameter of leaf midvein, thickness of palisade tissue, thickness of phloem and xylem vessel and diameter of vascular bundles, were measured.

**Statistical analysis:**

The obtained data were subjected to analysis of variance according to Snedecor and Cochran (1980) and means were differentiated using Duncan multiple tests at the level of probability 5% (Duncan 1955).

## RESULTS and DISCUSSION

**[ I ]-Vegetative growth parameters**

The effect of irrigation with different levels of saline water at SAR 6 & 12 and foliar application of phosphorus " P " (at the highest level of salinity) and SAR 6 , 12 on vegetative growth parameters of Jojoba seedlings were tested and evaluated under the same experimental condition in both 2002 and 2003 seasons.

**Stem length(cm) and its rate of increase(cm/season)**

The date presented in Table (2) clearly show that, the reduction of stem length was closely associated with increasing salt concentration and SAR in irrigation water. Irrigation with saline water at 4000 ppm, resulted in the least significant effect on stem growth, where its rate of increase recorded at SAR 6 (10.31&10.08) and at SAR 12 (10.12& 9.793) comparing with control (10.72 & 10.33) in 2002 & 2003 seasons respectively.

The maximum growth reduction was obvious at the highest concentration (8000 ppm and SAR 12) without phosphorus sprays (4.69 & 4.14) in both seasons respectively. However, data of the present study also revealed, positive influence of phosphorus treatment on the growth of seedlings grown under such highest level of salinity at SAR 6 & 12 which exhibited significant increase in stem growth comparing with those without P spray in both seasons.

These results agree with Bernstein *et al.*, (1974) who pointed out that the accumulation of specific ions such as sodium and chloride in different plant tissues would probably exert an inhibitory effect on plant growth and development. Similarly. Awad *et al.*,( 1990 ) , reported that phosphorus treatments reduced the salt damage .

**Number of leaves/plant, leaf area(cm)$^2$ and assimilation area(cm$^2$/plant):**

As shown in Table (2) average number of leaves / plant and leaf area were significantly decreased with increasing salt concentrations and SAR in irrigation water. In seedlings treated with different salt concentrations, the maximum total leaves number / plant (149.10 & 156.34) and leaf area (5.86 & 6.15) were obtained in seedlings irrigated with 4000 ppm and SAR 6 , in contrast to those irrigated with 8000 ppm and SAR 12 (The highest salt stress) without P sprays (97.18 & 107.51) and (4.55 & 4.86) comparing with untreated seedlings which recorded the highest values of both number of leaves / plant (151.95 & 157.70) and leaf area (6.020 & 6.51) in 2002 &2003 respectively.

No visual salt damage of leaves could be detected in any of the Jojoba seedlings ,whereas the survival percentage was 100 % in all treated plants. It seems that, although salinity treatment reduced vegetative growth, Jojoba seedling could tolerate salt concentrations in irrigation water up to 8000 ppm and SAR 12 , although vegetative growth was significantly reduced under salinity treatment, this observation, is coinciding with Yermanos *et al.*, ( 1967) and Benzioni *et al.*, (1996) on Jojoba clones irrigated with saline water.

The results also showed that, phosphorus sprays resulted a significant increase in leaf area, number of leaves per plant and assimilation area with Jojoba seedlings irrigated with saline water at 8000 ppm with SAR 6 & 12 as compared with those without phosphorus application.

**Fresh and dry weight of leaves(g) :-**

Concerning the effect of salinity stress on fresh and dry weight of the leaves, data presented in Table (3) indicated that, increasing salt concentrations in irrigation water resulted in an increase in fresh weight of leaves which recorded at 8000 ppm 0.367 & 0.363 with SAR 6 and 0.367 & 0.347 with SAR 12 , comparing with control 0.237 & 0b257 in two seasons respectively, which was mainly due to an increase in tissue water content reflected in the change in fresh: dry weight ratio of leaves from 2.862 and 2.761 in control to 4.342 and 4.799 in plants irrigated with saline water at 8000 ppm and SAR 12 without P application. Moreover , dry weight of leaves under such highest salt level was significantly reduced as compared with those at lower salinity level These findings go in parallel with the present results that increasing salinity level resulted in a significant reduction in assimilation area . Moreover, the great reduction in leaf area under the highest salinity level and subsequently in transpiration rate could be responsible for increasing the fresh weight of leaves . However, Storey and Wyn- Jones (1979) found that, salts induced synthesis of additional organic material made only a small quantitative contribution to the total increase in fresh weight and the improved morphological appearance of the plant.

**Fresh and dry weight of stem and roots :-**

Results reported in Table (4) clearly show that the different salt concentrations in irrigation water resulted in significant reduction in fresh and dry weight of stem and roots of Jojoba plants as compared with control plants in the two studied seasons. Salted irrigation water at 8000 ppm and SAR 12 had the greatest adverse effect on stem and root weight , followed by 6000 ppm then 4000 ppm

The data also indicated that, treating the seedlings growing under 8000 ppm Na Cl by phosphorus sprays apparently tended to minimize the such retorting effect of salinity in reducing the fresh and dry weight of stem and roots.

These results coincide with, Benzioni *et al.*, (1992) who showed that Na CL is preferentially accumulated in Jojoba leaves without causing visible damage. In this respect, Jojoba resembles crops like cotton or typical halophytes ( Storey and Wyn Jones 1979 ; Brugnoli and Bjorkman 1992).

Table (2): Effect of irrigation with different concentrations of saline water and P treatment on stem length and its rate of increase, number of leaves/plant, leaf area and assimilation area of jojoba seedlings (2002 and 2003 seasons).

| Parameters / Treatment | Stem length (cm) | | Rate of increase | | N. of leaves/plant | | Leaf area (cm2) | | Assimilation area ($cm^2$/plant) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 40.44 A | 43.06 A | 10.72 A | 10.33 A | 151.95A | 157.70A | 6.20 A | 6.51 A | 942.09A | 1026.63A |
| 4000 ppm SAR6 | 39.52 B | 43.11 A | 10.31 B | 10.08 B | 149.10B | 156.34B | 5.86 B | 6.15 B | 873.73B | 961.44 B |
| 4000 ppm SAR12 | 38.75 C | 42.45 B | 10.12 C | 9.79 C | 143 97C | 155.02C | 5.54 D | 5.87 C | 797.59C | 909.97 C |
| 6000 ppm SAR6 | 37.72 D | 40.69 C | 8.97 E | 8.67 E | 124.55E | 148.00D | 5.08 F | 5.14 E | 632.71E | 760.72 D |
| 6000 ppm SAR12 | 35.63 G | 37.06 D | 7.92 F | 7.39 F | 108.59G | 133.74E | 4.76 G | 5.07 F | 516.89F | 678.06 F |
| 8000 ppm SAR6 | 33.71 H | 36.64 E | 6.01 G | 5.46 G | 96.19 I | 115.20H | 4.64 H | 4.89 G | 446.32G | 563.33 G |
| 8000 ppm SAR6 + P | 37.61 E | 41.04 C | 9.36 D | 8.91 D | 127.59D | 130.46F | 5.67 C | 5.78 D | 723.43D | 754.06 D |
| 8000 ppm SAR12 | 32.91 I | 35.59 F | 4.69 H | 4.14 H | 97.18 H | 107.51I | 4.55 I | 4.86 G | 442.17G | 522.50 H |
| 8000 ppm SAR12 + P | 37.19 F | 40.69 C | 8.98 E | 8.77DE | 119.75F | 128.11G | 5.32 E | 5.75 D | 637.07E | 736.63 E |

Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.

Table (3): Effect of irrigation with different concentrations of saline water and P treatment on fresh and dry weight of leaves and leave fresh /dry weight ratio of jojoba seedlings (2002 and 2003 seasons).

| Parameters / Treatment | Leaves fresh weight | | Leaves dry weight | | Fresh weight /dry weight ratio | | Leaf fresh weight | |
|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 35.83 A | 40.25 A | 12.52 A | 14.58 A | 2.862 H | 2.761 F | 0.237C | 0.257C |
| 4000 ppm SAR6 | 35.37 C | 39.59 B | 11.90 B | 14.27 B | 2.972 G | 2.774 EF | 0.237 C | 0.250C |
| 4000 ppm SAR12 | 35.67 B | 39.36 C | 11.61 C | 13.89 C | 3.072 FG | 2.834 EF | 0.248 C | 0.250C |
| 6000 ppm SAR6 | 34.63 E | 37.79 F | 10.36 E | 13.12 D | 3.343 D | 2.880 E | 0.276 B | 0.256C |
| 6000 ppm SAR12 | 32.38 F | 36.73 G | 8.920 F | 11.54 F | 3.630 C | 3.183 D | 0.297B | 0.277BC |
| 8000 ppm SAR6 | 35 49 BC | 39.62 B | 8.343 G | 9.323 H | 4.254 B | 4.250 B | 0.267A | 0.347A |
| 8000 ppm SAR6 + P | 35.08 D | 38.56 E | 11.55 C | 11.86 E | 3.037 EF | 3.251 D | 0.378 B | 0.280bc |
| 8000 ppm SAR12 | 35.69 AB | 38.74 D | 8.223 G | 8.073 I | 4.342 A | 4.799 A | 0.367A | 0.363A |
| 8000 ppm SAR12 + P | 34.62 E | 37.46 F | 11 32 D | 10.12 G | 3.058 E | 3.701 C | 0.287B | 0.300B |

Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.

**Table (4): Effect of irrigation with different concentrations of saline water and P treatment on fresh and dry weight of stem and roots of jojoba seedlings (2002 and 2003 seasons).**

| Parameters / Treatment | Stem fresh weight | | Stem dry weight | | Root fresh weight | | Root dry weight | |
|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 29.43 A | 32.70 A | 12.19 A | 14.00 A | 22.11 A | 23.31 A | 10.33 | 10.93 |
| 4000 ppm SAR6 | 28.69 B | 31.62 B | 12.01 A | 13.73 B | 21.37 B | 22.74 B | 10.09 | 10.72 |
| 4000 ppm SAR12 | 28.40 C | 30.18 C | 11.21 B | 13.07 C | 19.80 D | 22.81 B | 9.997 | 10.24 |
| 6000 ppm SAR6 | 25.60 D | 27.31 E | 9.503 D | 11.46 E | 17.32 E | 21.51 C | 7.957 | 8.80 |
| 6000 ppm SAR12 | 22.57 F | 26.48 F | 8.703 E | 10.46 F | 16.15 F | 19.36 D | 6.793 | 8.427 |
| 8000 ppm SAR6 | 19.07 G | 22.33 G | 7.743 F | 9.143 G | 15.01 G | 18.96 E | 6.223 | 7.217 |
| 8000 ppm SAR6 + P | 25.51 D | 28.38 D | 10.60 C | 12.53 D | 20.57 C | 23.08 AB | 9.107 | 10.88 |
| 8000 ppm SAR12 | 16 10 H | 17.30 H | 6.240 G | 7.703 H | 14.79 G | 18.14 F | 6.453 | 7.193 |
| 8000 ppm SAR12 + P | 24.36 E | 26.88 F | 9.90 D | 11.43 E | 19.67 D | 21.23 C | 8.537 | 9.383 |

Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.

The increase in salt tolerance caused by P application supports the findings of several experiments where P was applied to soil (Awad *et al.*, 1990 and Ali 1999) or supplied via the leaves (Malakondairh and Rajesworarao 1979).

From the above mentioned results , it can be concluded that, growth parameters of jojoba seedlings were responded to salinity of irrigation water up to 8000 ppm and SAR 12 without causing visual damage in vegetative growth. So, these results proved that Jojoba seedling could tolerate different concentrations of saline irrigation water.

**[ 2 ]- Physiological aspects :**

**Osmotic potential:**

Data presented in Table ( 5 ) clearly showed that increasing salt concentrations in irrigation water for jojoba seedlings resulted in significant increase in the leaf osmotic potential of treated seedlings in both studied seasons. Result indicated that spraying phosphorus for seedlings grown at 8000 ppm and SAR 6,12 significantly decreased leaf osmotic potential comparing with that un- sprayed, on the other hand the results showed a significant increase of osmotic potential in P application seedling as compared with control ones. In this concern, Hsiao *et al.*, ( 1976 ) found that, solids accumulation in plant cells creates an intracellular osmotic potential which in the presence of a rigid cell wall generates turgid pressure. Maintenance of turgid pressure is necessary for continued growth through cell elongation. Hence an improved capacity for osmotic adjustment through increased ion uptake and compartmental may explain the P enhancement of tomato growth under saline condition (Awad *et al.*, 1990 ).On the other hand, accumulation of inorganic ions for osmotic adjustment is an energy effective way for higher plants to combine productivity with salt tolerance and is a feature of terrestrial halophytes (Yeo, 1983).

**Table (5): Effect of irrigation with different concentration of saline water on leaf osmotic potential and leaf succulence of jojoba seedlings during 2002 and 2003 seasons .**

| Treatments | Leaf osmotic potential | | Leaf succulence | |
|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 |
| Control | 12.12 H | 11.94 E | 0.249 F | 0.252 |
| 4000 ppm SAR 6 | 12.80 G | 12.80 D | 0.268 EF | 0.258 |
| 4000 ppm SAR 12 | 14.05 E | 13.87 C | 0.287 E | 0.273 |
| 6000 ppm SAR 6 | 14.93 D | 14.05 C | 0.387 C | 0.326 |
| 6000 ppm SAR 12 | 15.47 C | 14.57 B | 0.451 B | 0.376 |
| 8000 ppm SAR 6 | 16.05 B | 14.58 B | 0.604 A | 0.543 |
| 8000 ppm SAR 6+P | 12.45 GH | 13.71 C | 0.331 D | 0.356 |
| 8000 ppm SAR 12 | 16.88 A | 15.29 A | 0.621 | 0.593 |
| 8000 ppm SAR 12+P | 13.33 F | 13.87 C | 0.361 | 0.385 |

**Means for a given parameter followed by different litters are significantly different at level, p= 5% according to DunCan's new multiple range test.**

**Leaf Succulence Grade (LSG) :-**

It is clear from the results presented in Table ( 5 ) that, increasing salinity concentration in irrigation water resulted in a significant increase in leaf succulence grade of the treated seedlings .The highest values (0.604 &0.543) and (0.621 &0.593) was obtained when plants treated with saline water at 8000 ppm and SAR 6 &12 without P application in two seasons respectively ,followed in decreasing order by those under 6000, 4000, and 400 (control) ppm. These results are in harmony with those reported by David and Park(1979) who pointed that raising the concentration of NaCl in hydroponic solutions resulted in greater leaf succulence (mg $H_2O/cm^{-2}$)

**[ 3 ] -Chemical constituents**

**1-Foliar pigments content (chlorophyll a , b and carotene):**

The effect of irrigation with different concentration of saline water and foliar treatment of phosphorus on the leaf contents of chlorophyll a , b and carotene of Jojoba seedling are shown in Table ( 6 ).

The results revealed that, chlorophyll a , b and carotene content in jojoba leaves were significantly decreased with increasing salinity levels comparing with control seedlings in both seasons. Such depression was more pronounced at 8000 ppm salt level than that at 6000 ppm or 4000 ppm . Moreover, it was noticed that chlorophyll (b) content showed greater depletion due to salt treatment than chlorophyll ( a ) or carotene contents. It is noticed that phosphorus sprays improved leaves content of chlorophyll( a) , (b) and carotene of Jojoba seedling irrigated with saline water at 8000 ppm and 6 or 12 when compared with saline treatment only .

These results agree with those previously reported by Divate and Pandy (1981); El- sherif *et al.,* (2000),they all concluded that salinity stress condition reduced the concentration of leaf pigments content. In this concern, Gaser (1992) indicated that, irrigation of grapevine rootstocks with saline water greatly affected photosynthesis process, via inhibiting pigment formation . With respect to the influence of phosphorus treatment Youssif (1998) found that ,total leaf chlorophyll ( a and b ) content was positively influenced by the application of phosphorus.

**2 -Total soluble sugars:**

Results in Table (6) revealed that increasing the salinity levels significantly increased the leaf total soluble sugars content of Jojoba seedlings comparing with that in control in both studied seasons. These results are in agreement with those reported by youssif (1998) who concluded that salinity increased the total soluble sugars content. As for P treatment, the data clearly show that, phosphorus application significantly reduced sugars in jojoba salt-stressed as compared with those irrigated with saline water only in both seasons. These results agree with those reported by Gibson (1988) and Youssif (1998) that adequate phosphorus nutrition reduced sugars of salt stressed plants.

**3-Proline content: -**

Data presented in Table (6) indicated that increasing salt concentration in irrigation water significantly increased proline content in leaves of Jojoba seedlings comparing with that in control plants. whereas, seedlings irrigated with the highest salt concentration (8000 ppm, SAR 12), had the highest amount of leaf proline content ( o.450 & o.410).

With respect to **P** treatment, it caused a significant decrease in praline content in jojoba seedlings compared with those only irrigated with the saline water. Whereas proline content greater in jojoba seedlings treated with phosphorus than that in control.

The above mentioned results are in line with Bates *et al.*,(1973) ; Stewart and lee (1974), who mentioned that proline was increased gradually as levels of salinity raised ; they also suggested that, proline function as a source of solids for intracellular osmotic adjustments under saline conditions.

**4 -Mineral contents:-**

**a) Sodium and chloride content**

Results revealed that Sodium and Chloride were significantly accumulated in jojoba leaves in response to the increase in salinity level of irrigation water (Table 7 ). The amount of $Na^+$ and $Cl^-$ uptake by jojoba plants seem to be the highest under the high salinity level ( 8000 ppm and SAR 12 ) ,comparing with other tested salinity levels in the two seasons. These results supported the previous findings by Benzioni *et al.*,(1996) .

The results clearly showed that phosphorus sprays significantly decreased sodium and chloride concentration in leaves of jojoba seedling irrigated with saline water 8000 ppm and SAR 6 &12 comparing with those under the same salinity levels without P sprays. These results agree with Awad *et al.,* (1990) who suggested that increasing phosphorus fertilization enhanced the tolerance of plant to NaCl salinity stress possibly due to accumulation of ions for osmotic adjustment besides the restriction of sodium and chloride accumulation in immature leaves.

**b) Nitrogen, phosphorus and potassium content .**

As for leaf nitrogen and phosphorus content in Jojoba seedling as influenced by increasing salinity level in irrigation water, results in both seasons showed significant reduction in the N and P content in leaves of Jojoba plants compared with the control ones.

These results go in line with those reported by Awad *et al.*. (1990) and Benzioni *et al.,* (1996).

The concentration of potassium was slightly affected by the salinity treatments. The concentration of $K^+$ was 1.680 & 1.593 in the leaves of control plants and 1.537 & 1.487 in the leaves of plants treated with the highest salinity level without P application in 2002 and 2003 seasons respectively. Results also showed that, Sodium : Potassium ratio in the leaves were increased under salinity plants .

Concerning the effect of phosphorus sprays on minerals content of Jojoba leaves, results clearly show that P treatment resulted in higher leaf N , P and K content of jojoba seedlings than their analogous without P sprays . Moreover, P application in salinized plants resulted in a significant reduction in sodium and chloride contents in leaves of Jojoba seedlings irrigated with saline water at 8000 ppm (SAR 6 , 12) as compared with those without P treatment.

Table (6): Effect of irrigation with different concentrations of saline water and P treatment on leaf chlorophyll a, b and carotene as mg/gm fresh weight, total sugars (mg/gm dry weight) and proline content (g/100g fresh weight) of jojoba seedlings (2002 and 2003 seasons).

| Parameters | Chlorophyll a | | Chlorophyll b | | Carotene | | Total sugars | | Proline | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 1.562 A | 1.670 A | 0.832 A | 0.814 A | 0.620 A | 0 669 A | 5.747 H | 5.663 H | 0.227 E | 0.210 G |
| 4000 ppm SAR6 | 1.369 B | 1.423 B | 0.519 B | 0.593 B | 0 541 BC | 0.523 BC | 6.140 G | 5.950 G | 0.257 DE | 0.243 F |
| 4000 ppm SAR12 | 1.364 B | 1.412 B | 0.427 D | 0.442 D | 0.519 BC | 0.519 BC | 6.623 F | 6.363 F | 0.277 D | 0.267 EF |
| 6000 ppm SAR6 | 1.311 C | 1.321 B | 0.407 DE | 0.429 DE | 0.512 C | 0.516 BC | 6.910 D | 6.833 E | 0.310 C | 0.297 DE |
| 6000 ppm SAR12 | 1 292 C | 1.307 B | 0.390 EF | 0 407 E | 0.473 D | 0.485 CD | 7.127 C | 7.257 C | 0.357 B | 0.350 B |
| 8000 ppm SAR6 | 0.913 F | 0.928 C | 0.389 EF | 0.398 EF | 0.421 E | 0.420 EF | 8.660 B | 8.750 B | 0.443 A | 0.413 A |
| 8000 ppm SAR6 + P | 1 242 D | 1.249 B | 0 491 BC | 0 493 C | 0.546 B | 0.554 B | 6.563 F | 6.937 D | 0.310 C | 0.317 CD |
| 8000 ppm SAR12 | 0 917 F | 0.932 C | 0.362 F | 0.372 F | 0.391 E | 0.389 F | 8 857 A | 8.987 A | 0.450 A | 0.410 A |
| 8000 ppm SAR12 + P | 1.205 E | 1.247 B | 0.481 C | 0.493 C | 0.456 D | 0.460 DE | 6.753 E | 6.950 D | 0.357 B | 0.347 BC |

Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.

Table (7): Effect of irrigation with different concentrations of saline water and P treatment on concentration of leaf minerals (Na, Cl, N, P and K) and Na/K ratio of jojoba seedlings (2002 and 2003 seasons).

| Parameters | Na | | Cl | | N | | P | | K | | Na/K | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 0.173 H | 0.183 H | 0.223 I | 0.263 G | 2.880 A | 2.920 A | 0.660 A | 0.680 A | 1.680 A | 1.593 A | 0.103 H | 0.115 G |
| 4000 ppm SAR6 | 0.443 G | 0.500 G | 0.373 H | 0.400 F | 2.8 BC | 2.827 B | 0.623 BC | 0.627 BC | 1.667 AB | 1.573 AB | 0.266 G | 0.318 F |
| 4000 ppm SAR12 | 0.590 E | 0.630 F | 0.540 G | 0.570 E | 2.777 C | 2.663 D | 0.597 C | 0.603 C | 1.643 B | 1.557 B | 0.359 E | 0.405 E |
| 6000 ppm SAR6 | 0.727 D | 0.830 D | 0.757 D | 0.770 D | 2.533 E | 2.513 E | 0.553 D | 0.567 D | 1.607 C | 1.517 C | 0.452 D | 0.547 D |
| 6000 ppm SAR12 | 0.890 C | 0.297 C | 0.997 C | 1.153 C | 2.360 F | 2.313 F | 0.520 E | 0.520 E | 1.603 C | 1.507 C | 0.555 C | 0.615 C |
| 8000 ppm SAR6 | 1.230 B | 1.290 B | 1.167 B | 1.247 B | 2.107 G | 2.163 G | 0.487 F | 0.463 F | 1.557 D | 1.487 C | 0.790 B | 0.868 B |
| 8000 ppm SAR6 + P | 0.507 F | 0.637 F | 0.650 F | 0.743 D | 2.810 B | 2.850 B | 0.637 AB | 0.657 AB | 1.660 AB | 1.580 AB | 0.305 F | 0.403 E |
| 8000 ppm SAR12 | 1.337 A | 1.407 A | 1.227 A | 1.297 A | 2.040 H | 2.070 H | 0.437 G | 0.443 F | 1.537 D | 1.487 C | 0.870 A | 0.946 A |
| 8000 ppm SAR12 + P | 0.620 E | 0.677 E | 0.687 E | 0.770 D | 2.730 D | 2.790 C | 0.610 BC | 0.647 B | 1.633 BC | 1.570 AB | 0.380 E | 0.430 E |

Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.

The requirement for P application in salinized plants could be related to its role in energy fixation and carbohydrate partitioning and its transport (Bieleski and Ferguson 1983; Gibson 1988). However P is also involved in the formation of cell membrane lipids , which play a vital role in ionic regulation (Bieleski and Ferguson 1983) .

In conclusion salt tolerance in Jojoba may be related to its ability to accumulate $Na^{+}$ and $Cl^{-}$ at high concentrations in leaves without causing visible damage. In addition accumulation of Na and Cl in Jojoba leaves may be indicate the utilization of both ions for osmotic adjustment in vacuoles and improve the water balance.

It should be, emphasized that Jojoba is considered to be a salt-tolerant plants which can survive well under salinity stress and the response of Jojoba to salt concentration in irrigation water depends also on irrigation management, soil properties and climatic factors ; each of them should contribute in the growth and survival of plants under saline conditions.

**[ 4 ]Anatomical Studies** :

**Anatomical structure of leaf** :

The structure of the leaf blade was briefly described by Metcalf and Chalf (1950) and described in some details by Bailey (1980).

Cross section of the leaf blades are shown in Fig ( 1 ) revealed that, the leaf of jojoba seedling consisted of three layers :

**1- The epidermis** , its cells are rectangular and procumbent, cell size is uniform throughout each epidermis . The cuticle evenly distributed over the upper and lower epidermial surfaces . Stomata are evenly distributed over each leaf epidermis , and it slightly sunken . Similar finding was reported by Metcalfe and Chalf (1950) ;Bailey (1980).

**2-The mesophyll :**

The mesophyll is isolateral and organized completely as palisadelike tissue , it consists of two concentric regions surrounding a third each region oblong in outline ( Fig 1 ) . These findings agree with previously reported by Bailey (1980).

The outermost mesophyll region, is of 3-4 cell layers thick and is subjacent to each epidermis . Cells recorded 4.167 µm in length and 1.833 µm in width . Bailey (1980) suggested that outermost mesophyll region is most likely the major site of photosynthesis since the cells border on the epidermis ,hence ,are the mesophyll cells closest to the source of light, tannins are commonly absent ,the deposition of which could limit or prevent photosynthesis .

Second mesophyll region ( The tanniferous layers ), cells of the second mesophyll region are larger than those of the outermost layer and contained abundant tannins , this mesophyll region is completely developed in seedlings which irrigated with saline water at 8000 ppm. Bailey (1980) reported that this region was designated for storage of the tanniferous materials .

Innermost mesophyll region, the innermost mesophyll region is surrounded by tanniferrous layer where vascular bundles were situated. Cells in that region contain tannins in their cells .

**3-Vascular bundles and vascular tissue of the primary vein,** are collateral (xylem adaxial, phloem abaxial), except within basal and medial portions of the blade where the vascular tissue of the primary vein is bi-tripartite. These results in general are in harmony with those reported by Bailey (1980).

**Effect of different salinity levels on the structure of jojoba :-**

The effect of different salinity on the leaf structure of jojoba seedlings are illustrated in Table ( 8 ) and Fig ( 1&2 ). The data showed a significant difference in sectors of treated and untreated plants, where leaf blade thickness and axial diameter of leaf midvein increased with increasing salinity level in irrigation water. the maximum increase was recorded in leaf of seedlings irrigated with 8000 ppm . The values of mesophyll thickness showed the same trend of leaf thickness with the different salinity levels. These results agree with David and Park (1979) they reported that , increasing in leaf thickness can be induced by exposure of roots to high concentration of NaCl ,they also suggested that, such salt induced succulence could lower the resistance to $CO_2$ uptake and thus increased photosynthetic rate by increasing the amount of internal leaf surface area across which gaseous exchange can occur per unit leaf area.

**Table (8): Effect of irrigation with different concentration of saline water on leaf anatomy of jojoba seedlings .x=144**

| Treatments | Thickness of sum upper and lower | | Mesophyll thickness | Cell of the outer most mesophyll region | | Cells in the second mesophyll region | |
|---|---|---|---|---|---|---|---|
| | Cuticle | Epidermis | | Length | Width | Length | Width |
| Control | 2.667 | 3.333 | 66.67 D | 4.167 C | 1.833 C | 7.333 D | 2.667 D |
| 4000 ppm | 2.667 | 3.500 | 74.67 DC | 5.50 B | 2.833 BC | 9.333 C | 3.333 C |
| 6000 ppm | 2 833 | 3.500 | 82.67 B | 7.50 A | 3.167 B | 10.67 B | 4.667 B |
| 8000 ppm | 2.760 | 3.507 | 106.7 A | 7 833 A | 3.333 A | 14 33 A | 5 333 A |

**Table (8): Continued.**

| Treatments | Axial diameter of leaf midvein | Diameter of xylem vessel | Thickness of phloem | Leaf blade thickness | Diameter of vascular bundles |
|---|---|---|---|---|---|
| Control | 74.33 D | 22 00 C | 6.833 | 73.33 D | 32.67 B |
| 4000 ppm | 82.67 C | 21.67 C | 7.000 | 81 33 C | 32. 00 B |
| 6000 ppm | 92.67 B | 23.00 B | 6.933 | 89.00 B | 36.86 A |
| 8000 ppm | 115 3 A | 24.00 A | 6.967 | 111.7 A | 43.00 A |

**Means for a given parameter followed by different litters are significantly different at level p= 5%, according to DunCan's new multiple range test.**

Non significant difference in the thickness of cuticle and epidermis recorded in leaf of treated and untreated seedlings .In the present study, great changes were noticed in the features of the mesophyll cells with salinity treatments ,where the cells in the outermost mesophyll region and the tanniferrous layers increased in length and width ,thus the thickness of these layers increased by increasing salinity levels , the cells of the second mesophyll region was appeared and increased in seedlings irrigated with saline water at 8000 ppm and arranged as the tanniferous materials layers comparing with control where this tanniferous materials were scattered .

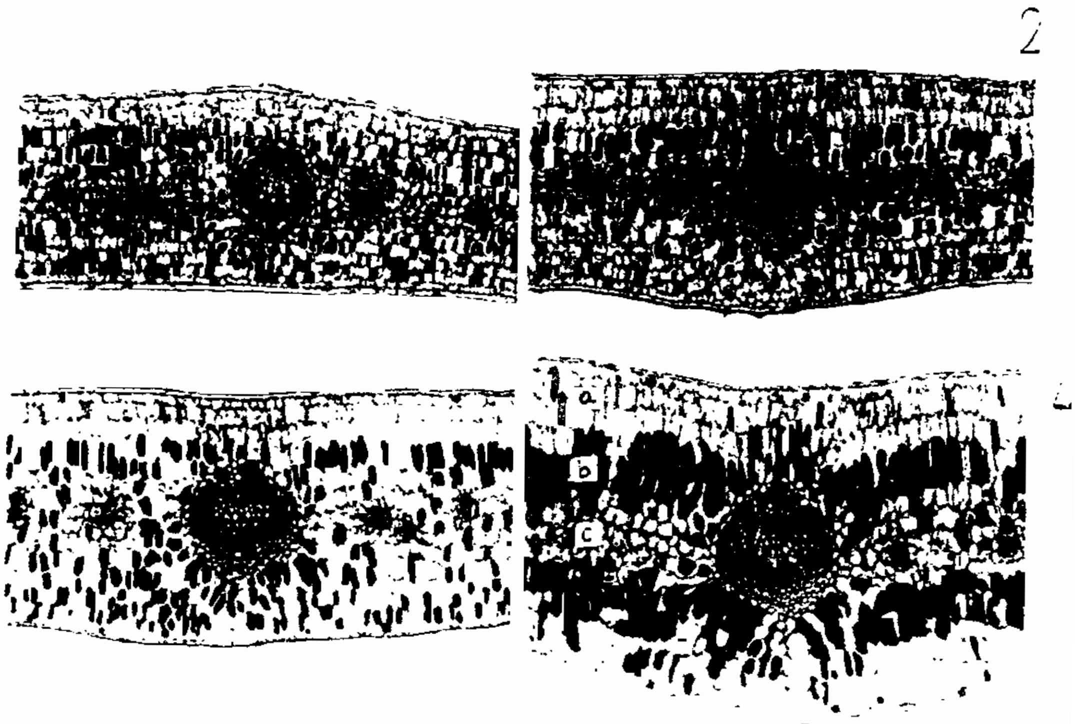


Fig.( 1 ) : Effect of different salinity levels on leaf blade anatomy of jojoba seedlings,showing the different responses to graded levels of salinity. 1) control 2)4000ppm 3) 6000ppm 4)8000ppm (showing the arrangement of the mesophyll as a results of salt stress) a)The outermost mesophyll region b)The tannife ous layers c)The innermost mesophyll region ( X 52 )

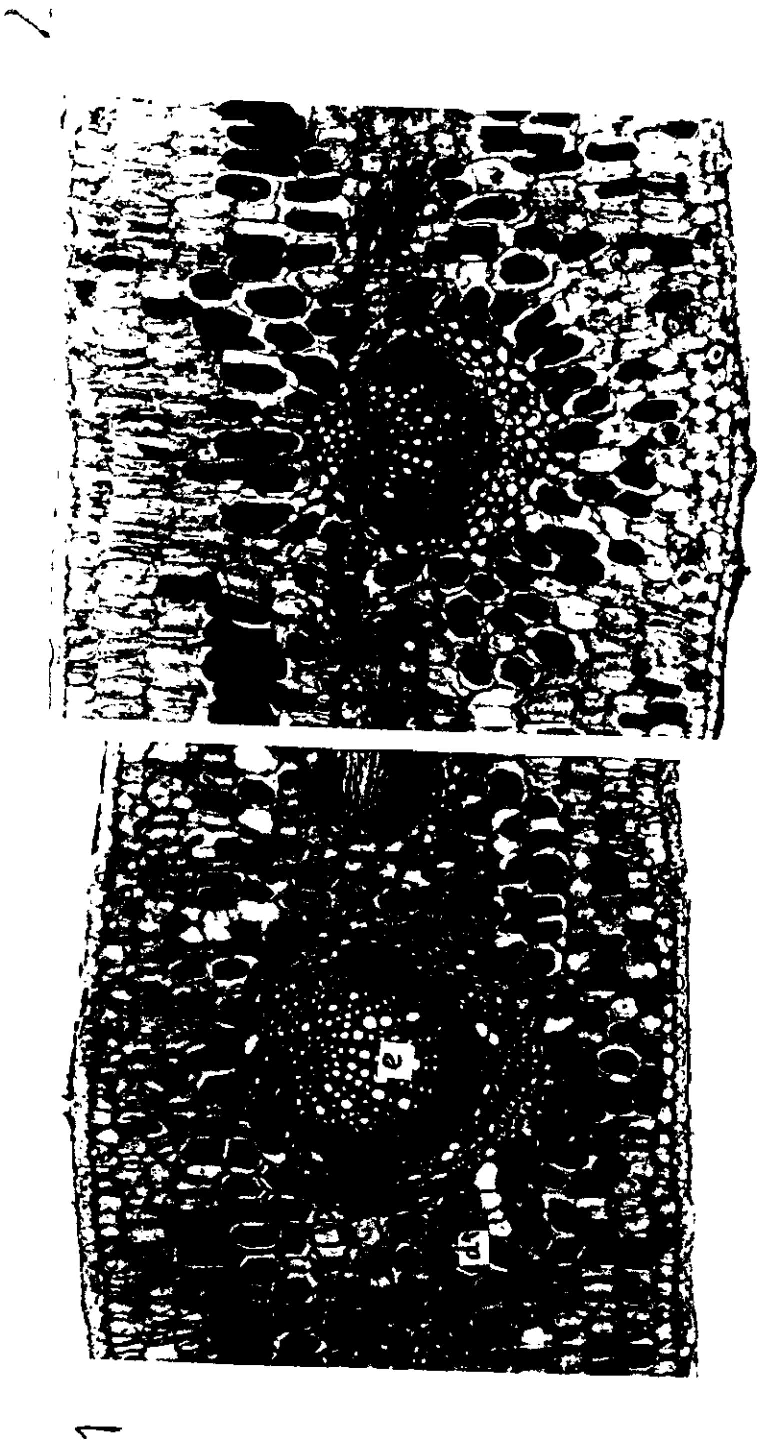


Fig.( 2) : Effect of different salinity levels on leaf midvein anatomy of jojoba seedling 1) control 2) 4000 ppm , d) druse-bearing idioblasts e) Vascular bundles ( X 144 )

4

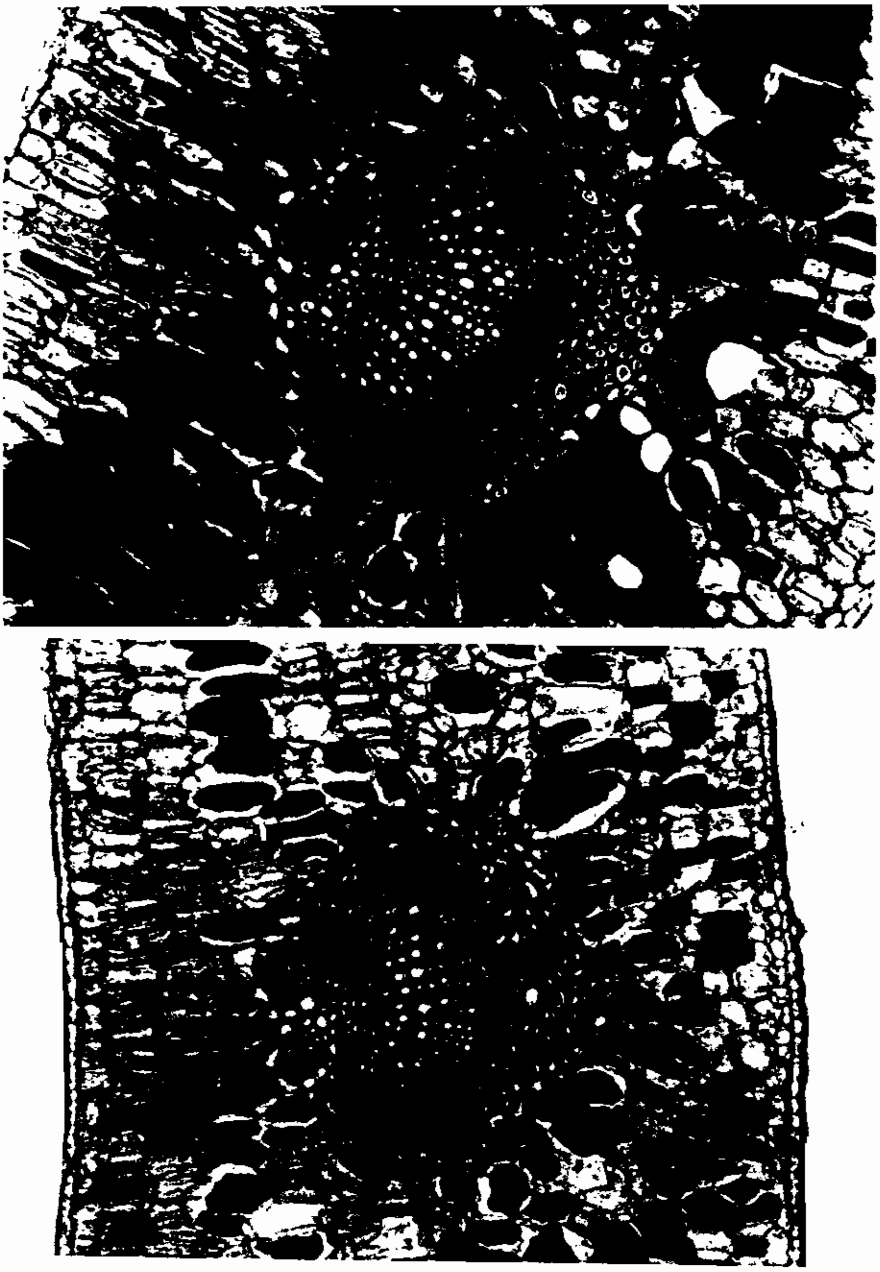

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Fig.(2) continued , 3)6000 ppm 4) 8000 ppm

Vascular bundles diameter clearly increased by increasing salinity levels , the obtained values ranged between 32.67 and 43.00 µm for control plants and those irrigated with saline water at 8000 ppm respectively . Concerning xylum thickness ,plants grown at 8000 ppm had greater xylum thickness than plants grown at 400 ppm (control ).

Finally the results obtained from morphological ,physiological , chemical and anatomical studies reveal that jojoba seedlings can survive well under different levels of salinity up to 8000 ppm .
Meanwhile ,it appeared to have some anatomical modification under both low and high salinity stress .

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**دراسات على تحمل شتلات الجوجوبا لمستويات مختلفة من الملوحة و نسبة الصوديوم المدمص متضمنة استجابتها للمعاملة رشا بالفوسفور لمقاومة الملوحه**

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**معهد بحوث البساتين – مركز البحوث الزراعية**

أجريت هذه الدراسة على شتلات نباتات الجوجوبا النامية في مشتل معهد بحوث البساتين بالجيزة خلال موسمي ٢٠٠٢ ، ٢٠٠٣ لدراسة :-

مدى استجابة الشتلات للري بالماء بمستويات مختلفة من الملوحة ( كنترول ، ٤٠٠٠ ، ٦٠٠٠ ، ٨٠٠٠ جزء في المليون ) عند مستوى نسبة صوديوم مدمص ٦ ، ١٢ وتأثير ذلك على الصفات المورفولوجية و الفسيولوجية والكيمائية و أيضا مدى تأثير المستويات المختلفة من الملوحة على التركيب التشريحي للورقة .

دراسة مدى استجابة النباتات بالمعاملة رشا على المجموع الخضري بالفوسفور (١٠٠٠جزء في المليون عند مستوى ٨٠٠٠ جزء في المليون مستوى نسبة صوديوم مدمص ٦ و١٢) في تقليل الإجهاد الملحي للشتلات .

**ويمكن تلخيص النتائج التي تم الحصول عليها فيما يلي**

أظهرت النتائج أن زيادة التركيز الملحي في ماء الري أدى إلى انخفاض في معدل النمو وعدد الأوراق / للنبات ومساحة الورقة (سم٢) والمساحة الفعالة (سم٢ / النبات) وكذلك الوزن الجاف للأوراق و الوزن الطازج و الجاف للساق والجذور

وعلى العكس من ذلك أظهرت النتائج زيادة في الوزن الطازج للورقة مع زيادة ملوحة ماء الري ويرجع ذلك إلى الزيادة في محتوى الأنسجة من الماء وينعكس ذلك على زيادة نسبة الوزن الطازج / الوزن الجاف للأوراق حيث أن هذه النسبة تعتبر مؤشر لزيادة درجة غضاضة الورقة .

أظهرت النتائج أيضاً أن الرش بالفوسفور عند مستوى ملوحة ٨٠٠٠ جزء في المليون وماء بنسبة صوديوم مدمص ٦ ، ١٢ أدى إلى تقليل التأثير الضار للملوحة على الشتلات .

لم يشاهد أي تأثير ضار على النمو الخضري لشتلات الجوجوب خلال موسمى الدراسة على الرغم من نقص النمو تحت ظروف الملوحة مما يدل على أن الجوجوبا لها القدرة على تحمل ملوحة مياةالرى حتى ٨٠٠٠ جزأفى المليون .

- أظهرت الدراسة أن زيادة مستويات الملوحة في ماء الري أدت إلى زيادة الضغط الأسموزى للورقة (LOP) ودرجة غضاضة الورقة (LSG) و زاد محتوى الأوراق من السكريات الكلية والحامض الأميني برولين و كذلك حدث تراكم للصوديوم و الكلوريد في الأوراق تحت تأثير المعاملة الملحية مقارنة بالشتلات الغير معاملة على العكس من ذلك اظهر محتوى الأوراق من

الصبغات النباتية كلوروفيل أ ، ب وكاروتين تناقصاً ملحوظاً وكذلك انخفضت نسبة النيتروجين والفوسفور والبوتاسيوم مع زيادة الملوحة في ماء الري أثناء موسمي الدراسة .

و كان للرش بالفوسفور تأثير إيجابي في زيادة قيم كلوروفيل أ & ب و الكاروتين و كذلك زيادة محتوى الأوراق من النيتروجين و الفوسفور و البوتاسيوم على العكس من ذلك انخفض محتوى الأوراق من البرولين و السكريات الكلية وكذلك نسبة الصوديوم و الكلوريد في الأوراق بالمقارنة بالشتلات المعاملة بنفس تركيز الملوحة فقط .

أظهرت الدراسة الميكروسكوبية أن ورقة الجوجوبا تتكون من ثلاثة طبقات : الإبيدرمس & الميزوفيل ( عبارة عن طبقتين من الخلايا العمادية تنحصر بينهما طبقة ثالثة من الخلايا توجد بها الحزم الوعائية ) والحزم الوعائية .

أدت المعاملة الملحية إلى زيادة سمك نصل الورقة وسمك العرق الوسطى وأيضا سمك طبقات الميزوفيل نتيجة كبر طول و عرض الخلايا في الطبقة الأولى و الثانية و كذلك زاد حجم الحزم الوعائية مقارنة بالشتلات الغير متأثرة بالملوحة و لم يحدث أي إضرار بالنسبة للخلايا ،بينما لم يحدث أى تأثير معنوى فى سمك الإبيدرمس والكيوتيكل فى جميع المعاملات بالمقارنة بالكنترول.

نستنتج من هذه الدراسة أن نبات الجوجوبا يعتبر من النباتات المقاومة للملوحة يمكن أن تنمو بصورة جيدة تحت تأثير مستويات عالية من الملوحة مقارنة بالنباتات الأخرى .