233
Arab Univ.
J. Agric. Sci.,
Ain Shams Univ.,
Cairo, 19(1), 233-244, 2011

ROLE OF POTASSIUM AND SALINITY EFFECTS ON GROWTH AND CHEMICAL COMPOSITIONS OF DATE PALM PLANTLETS

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Keywords: Potassium, Salinity, Proline, Date palm

ABSTRACT

A greenhouse pot experiment was carried out to investigate the effect of salinity and potassium at different levels alone or in various combinations on growth, mineral and proline content in leaves of plantlets of *Phoenix dactylifera* L. cv. Bartomouda (*in vitro* production, two years old from acclimatized them). The following treatments were applied: three levels of salinity Na Cl + Ca Cl_2 w.w 2:1 (14000, 16000 and 18000 ppm.) and two levels of potassium (2000 and 3000 ppm) in addition to control (no salts or potassium used), salts and potassium were added in the irrigation water. In general, all levels of salinity significantly decreased various growth parameters such as plant height, number of leaves and roots, root length, fresh and dry weights of leaves than that of the control. These parameters were decreased with increasing salinity levels, whereas it, significantly increased Na, Ca and K contents in leaves with high content of proline. The treatment 18000 ppm salts gave the highest significant reduction of the growth parameters, while caused an increase in proline Na, Ca, and K contents compared to control treatment (no salts) . This was true in both seasons. The applications of potassium significantly increased the previous growth parameters as compared with the control treatment (without salts and potassium) the treatment 3000 ppm had the highest results. Moreover the applications of potassium gave high alleviated the negative effects of salt stress, the treatment 3000 ppm gave the best results on the growth parameters of date palm plantlets grown under salinity condition . Regarding the interaction the obtained data revealed that the interaction between treatment 3000 ppm potassium and 14000 salts produced the highest significant results. Generally, from the obtained results it can conclude that the plantlets of date palm produced by tissue culture can be tolerated salt stress by addition of potassium which can significantly ameliorate the harmful effects of salts, positive effects on the growth parameters of the plantlets was showed by potassium applications.

INTRODUCTION

Date palm is considered a salt tolerance plant species, but the information of salt tolerance among the cultivars was very limited **Al- Mansoori *et al* (2007).** Increasing of salinity levels (NaCl) led to significant decreases in growth parameters, **El-Tantawy *et al* (2006)** on *Phoenix dactylifera* L. **Mahdavi and Sanavy (2007)** on *Lathyrus sativus*, **El-Araby *et al* (2008)** on Tomato, **Khalid *et al* (2008)** on *Cicer arietinum* L.)). Leaf content of Na, Ca and K was increased with increasing of salinity levels **Subbarao *et al* (2003)** and **Mahmoud and Athar (2008)** on *Panicum turgidum*, **Naeem *et al* (2006)** on Wheat**, Tsialtas and Maslaris (2006)** on sugar beets, **Sortiropoulos *et al* (2006)** on pear rootstocks and **Mickelbart *et al* (2007)** on avocado. Proline content took the same trend with salinity levels (**Bondok *et al* (1995)** on peach, **Wan *et al* (2006)** and **Sannazzaro *et al* (2007)** on *Lotus glaber*. The applications of potassium significantly increased the previously growth parameters and leaf mineral content and proline. Moreover **Sorial *et al* (2001)** on (*Mentha piperita*) peppermint, **Delgado and Sanchez (2007)** on sunflower and **Kaya *et al* (2007)** on *Cucumis melo* found that addition of potassium significantly ameliorated the adverse effects of salinity. This experiment aims to investigate the effect of potassium applications on growth parameters and leaf mineral content of date palm plantlets (produced by tissue culture) grown under salinity stress.

(Received October 24, 2010)
(Accepted January 16, 2011)

MATERIALS and METHODS

This study was conducted at the Central Laboratory for Research and Development of Date palm, Agriculture Research Center (ARC) Giza, in 2008- 2009, on plantlets of *Phoenix dactylifera* L. cv. Bartomouda produced by *in vitro* culture and acclimatized them in the greenhouse in plastic bags that contain sand: peatmoss 2:1 (Ec 3.06 ds/cm), these plantlets were nearly uniform and relative in size, growth and vigor (20-30cm height, 3-4 leaves, 20-25 cm for root length and 4-5 roots/plantlet) and used to study the effect of different levels of salinity and potassium (k^+) on growth parameters and leaf mineral and proline content. Three levels of salinity 14000, 16000 and 18000 ppm (NaCl + $CaCl_2$ 2:1 w.w) were applied alone or in combination with two levels of potassium 2000 and 3000 ppm (as potassium sulfate), in addition to control treatment. Salts and potassium were added in the irrigation water, three replicates were used for this experiment and three plantlets for each replicate. After six months from treatments the following data for each season were recorded:

1- Plant height cm. and number of leaves/ plantlet
2- Root length cm. and number of roots/plantlet
3- Fresh and dry weights of leaves
4- Proline content in leaves was determined as described by **Bates *et al* (1973)** as follows:

$$\textbf{Mg /g proline} = \frac{\textbf{ppm.x ml. extract}}{\textbf{2x g. samples x10}}$$

5- Na, Ca and K contents in leaves were determined as described by **Jackson (1973)**.

Results were subjected to analysis of variance using factorial experiments in a completely randomized design and L.S.D. (0.05) was used for comparison **(Snedecor and Cochran 1980).**

RESULTS AND DISCUSSION

The potassium cation takes a crucial part in many metabolic processes in the cell, It serves as an osmoregulator and participates in several processes that take care of the water management of plants. Potassium helps to built thicker cell walls, and increases the concentration of electrolytes inside the cell, thus increasing the plant's resistance. Since potassium is one of the most important macro- nutrients in plants, understanding the mechanisms of K+ uptake and transport is essential for revealing the controlling steps of plant growth and for improving crop yields even under unfavorable growth conditions such as salinity. For plants growing on saline soils, it is crucial to maintain the Na:K ratio by favoring the accumulation of potassium over sodium

Plant height (cm)

The results of both seasons **(Tables 1 and 2)** revealed that all levels of salinity (NaCl +$CaCl_2$) significantly decreased plant height than that of the control. Increasing salinity caused a decrease in plant height. In other words; plant height was decreased as levels of salinity increased. The significant highly reduction of plant height occurred at the treatment of 18000 ppm salts (93.0 and 99.3 cm respectively for 1^{st} and 2^{nd} seasons as compared with other treatments. Control treatment (no salts used) gave the highest results which produced 120 and 124.6 cm in 1^{st} and 2^{nd} seasons, respectively. These results are in accordance with those obtained by **El- Tantawy *et al* (2006)** on *Phoenix dactylifera* L **, Gherroucha *et al* (2003)** on wheat, **Seema and Amar (2008)** on *Acacia senegal***, Khalid *et al (*2008)** on *Cicer arietinum* plumule, **Zaki *et al* (2009)** on sweet fennel cultivars **Bhadauria and Kumar (2008)** on okra *Abelmoschus esculentus* L., and **Castro *et al* (2008)** on avocado *Persea Americana* Mill They all reported that salinity levels (NaCl) were decreased plant height and the decrement was indirect proportion with rising levels of salinity.

As for the alleviation effects of potassium on the negative effects of salinity (NaCl +$CaCl_2$), data of **(Tables 1 and 2)** also show that the applications of potassium stimulated the plant height compared to control treatment (salts only), the treatment 3000 ppm had the highest results of plant height (116.4 and 122.3 cm in the 1^{st} and 2^{nd} seasons respectively). More significant effective was in the interaction between 3000 ppm of potassium and 14000 ppm salinity (121.8 and 127.2cm) in 1^{st} and 2^{nd} seasons respectively. These results are in accordance with those obtained by, **Azza *et al* (2006)** on *Dalbergia sissoo*, and **Bajehbaj (2010)** on *Helianthus annuus* L. **Kaya *et al* (2007)** on *Cucumis melo* L. they reported that addition of some nutrients such as potassium and sulphur was significantly alleviated the adverse effects which induced by NaCl.

Number of leaves/plantlet

Results presented in **Tables (1 and 2)** reveal the same trends as observed on plant height, i.e. all salinity treatments significantly decreased the number of leaves/plantlet, as compared with the control in both seasons. Meanwhile, clear differences were detected between various levels of salinity and the decrease in number of leaves/ plantlet. The highest significant was reduction by the treatment 18000 ppm which gave 10.0 and 10.3 leaves/plantlet, compared to control treatment which gave the highest significant result (13.0 and 14.0) in the 1^{st} and 2^{nd} seasons respectively. These results were similar with, **Abdou *et al* (2006)** on sweet fennel, and **Kulkarni *et al* (2007)** on *Punica granatum* L. **Musyimi *et al* (2008)** on avocado **Al-Hamdani (2008)** on *puerana lobata* L and **El-Araby *et al* (2008)** on *tomato*, and more recently with **Muhammad and Hussain (2010)** on five medicinal plants (*Lepidium sativum* L., *Linum usitatissimum* L., *Nigella sativa* L., *Plantago ovata*Forssk, and *Trigonella foenum-graecum* L. They stated that, numbers of leaves of were decreased by levels of NaCl.

In regard to the effect of potassium on number of leaves/plantlet **(Table 1 and 2)** where salinity stresses was founded. The levels 3000 ppm potassium were produced the best results (13.7 and 14.3 leaves/plantlet) followed by 2000 ppm (11.6 and 12.3 leaves/plantlet) compared to control treatment (9.2 and 10.0 leaves/plantlet), respectively for 1^{st} and 2^{nd} seasons. The obtained data revealed that the interaction between treatment 3000 ppm potassium and 14000 salts were produced the highest significant results. These results are in harmony with those mentioned by **Badr *et al* (2005)**, **Sakr and Arafa (2009)** on *Brassica napus* L, **Kaya *et al* (2007)** on *Cucumis melo* L found that 48 kg/fed as K_2O or 5 mM to 0.8 g/pot as potassium sulfate or 5.6 cm3/l as a foliar application also spermine at 10 mg/l and ascorbic acid at 200 mg/l had a stimulating impact and may alleviate the effect on increasing the adverse effects of salinity.

Root length (cm)

Regarding the effect of salinity on average of root length, results from **Table (1 and 2)** reveal the same trends as observed in plant length, i.e. all salinity treatments significantly decreased root length than those of the control treatment. This was true in the two seasons of study. A lowest reduction was recorded at level 14000 ppm (30.5 and 31.2 cm), meanwhile the 18000 ppm gave the highest inhibition results (25.2 and 26.4 cm in the 1^{st} and 2^{nd} seasons respectively) comparable with the control treatment. Similar results were obtained by **Hokmabadi *et al* (2005)** on *Pistachio vera* L., **Kathiresan and Rajendran (2008)** on mangarove (*Rhizophora apicatata*) seedlings, **Jampeetong and Brix (2009)** on *Salvinia natans*, and **Prakash *et al* (2010)** on cowpea, they all reported that, increasing levels of salinity (NaCl at 50,100 and 150 mM) decreased root length.

In regard to the effect of potassium on root length under salinity conditions results presented in **Tables (1 and 2)** in both seasons indicated that the studied treatments of potassium mitigated the harmful effects of different levels of salinity ($NaCl+CaCl_2$) on the root length. The significant highest length of roots was noticed at 3000 ppm potassium (33.7 and 35.3cm. for 1^{st} and 2^{nd} seasons respectively) with the highest significant interaction with 14000 ppm of salinity compared to control treatment. These data were supported by, **Shirazi *et al* (2005)** on wheat who found that, an increase in the shoot and root length had occurred with application of K^+ (10 mmol Kcl/ds^3). The enhanced growth of these genotypes under saline condition might be due to the quick response to external K^+ application. In addition **Malakouti (2006)** stated that, K+ application under salinity conditions would improve root expansion and elongation of *Pistachio*, and also would increase the surface area contact between tree roots and soil nutrients.

Number of roots

Its shown from Table (3 and 4) that the significant inhibition effect of all levels of salinity (14000, 16000 and 18000 ppm NaCl+ $CaCl_2$) on roots number, the highest depression of roots number (6.6 and 7.5 roots/plantlet) was obtained by the treatment 18000 ppm., while the treatment of 14000 ppm gave the lowest significant reduction of number of roots (8.0 and 9.0 roots/plantlet) compared to control treatment which produced 8.5 and 9.7 roots/plantlet. In this respect, **Shibli *et al* (2003)** on *Prunus dulcis* and **Dashtakian and Bahrani (2007)** on *Rubia tinctorum* L stated that, roots number was decreased with rising salinity levels (NaCl), and **Kapoor and Srivastava (2010)** elucidated that number of roots of *Vigna mungo* were reduced by 2.5 % NaCl.

Regarding the effect of potassium on roots number results from **Tables (3 and 4)** proved that the highest significant stimulation effects of potassium on number of roots which was noticed at

3000 ppm potassium (9.1 and 10.6) followed by 2000 ppm (7.3 and 8.4) compared to control treatment (6.3 and 6.9 roots/plantlet) in the 1st and 2nd seasons, respectively. Highly significant interaction between 3000 ppm of potassium and 14000 ppm of salinity existed which had (9.6 and 10.8 roots/plantlet, in the 1st and 2nd seasons respectively). These data showed that potassium treatments enhanced some root parameters such as expansion and elongation under salinity stress, and then mitigated the harmful effects of salinity on plant growth.

Fresh and dry weights of leaves

Tables (3 and 4) revealed that exposure of plantlets of date palm to salinity levels at 14000, 16000 and 18000 ppm salts decreased fresh and dry weights of leaves compared to control treatment. Generally, increasing salinity levels decreased fresh and dry weights of leaves, the highest depression was obtained by the treatment 18000 ppm, such depression was statistically significant as compared with other treatments in the 1st and 2nd seasons. These results were confirmed by **Sahoo *et al* (2005)** who stated that, dry matter of marigold (*Tagetes erecta*) was decreased significantly with high salinity levels (NaCl), also results here were supported by **Ece and Atilla (2007)** on strawberry and **Ahmed (2008)** on wheat, **Rahman *et al* (2008)** on *Oryza sativa*, Cha-Um and **Kirdmanee (2009) and Emine *et al* (2010)** on *Zea mays* and **Amirjani (2010)** on soybean they reported that increasing of salinity 6-100 ds/m^2 reduced fresh and dry weights of shoots and roots.

In regard to the effect of potassium on fresh and dry weights of leaves under salinity conditions, results presented in the same **Tables (3 and 4)** indicated that the studied treatments of potassium mitigated the harmful effects of different levels of salinity ($NaCl+CaCl_2$). In this respect level 3000 ppm gave the highest significant result 8.5 and 9.3 for fresh weight and 3.7 g and 4.1 for dry weight respectively for 1st and 2nd seasons, compared to control treatment. Most significant interaction was obtained by the treatment 3000 ppm potassium with the level 14000 ppm of salinity (8.8 and 9.5 for fresh weight, and 3.9 and 4.2 g for dry weight, respectively for tow seasons). Similar results were obtained by **Yagmur *et al* (2007)** where they proved that potassium application had positive effects on salinity and alleviated the negative effects of salinity.

Proline content

Fig. (1 and 5) showed that the proline content in leaves was gradually increasing with rising salinity treatments. The treatment 18000 ppm had high increases of proline content (3.4 and 4.3 mg/g), compared to control treatment which recorded the lowest values (0.5 and 0.7 mg/g in the 1st and 2nd seasons, respectively). In this respect **Cardenas *et al* (2006)** on *Phaseolus vulgaris* L. showed that, the higher free proline content was found with (0.10 and 150 mM NaCl), **Arunothai and Hans (2008)** on *Salvinia natans*, **Najad *et al* (2008)** on *Pisum sativum* L, **Sakr and Arafa (2009)** on Canola plants (*Brassica nupus*), reported that proline accumulation in the presence of salt stress is a good indicator of stress perception. Higher proline content alleviated the negative effects germinated by salinity, allowing an adequate water economy and protecting photosynthetic tissues **Franco and Veliz (2007)**.In addition **Ashraf and Foolad (2007)** and **Plaza *et al* (2009)** on *Cordyline fruticosa*, noticed that proline is a more major organic osmolyte that accumulated in a variety of plant species in response to environmental stress such as drought and salinity.

Na, Ca and K^+ contents

Figs. (2, 3, 4, 6, 7 and 8) revealed that the leaves content of Na, Ca and K had the same tendency, which increasing with progressively raising of salinity levels. High levels of salinity 18000 ppm had a marked significant increase of each of these minerals content compared to the control treatment which recorded the lowest values for these minerals, in the 1st and 2nd seasons under study. These results were in agreement with **Prado *et al* (2006)** who stated that, K+ is an essential macronutrient and the most abundant inorganic cation in plant cells, whereas Na+ toxicity is a principal component of the deleterious effects associated with salinity stress, Similar results were obtained by **Silveira *et al* (2009)** on *Atriplex nummularia*, and **Tsialtas *et al* (2010)** on *Beta vulgaris*, **Genhua *et al* (2010)** on *Rosa* rootstock, they revealed that, Na and K were increased with increasing salinity and stated that, Na: K ratio in older leaves appears to be a useful marker for salinity tolerance.

Regarding the effect of potassium on leaf content of potassium under salinity conditions, results presented in the same Tables indicated that the studied treatments of potassium significantly increased the leaf content of potassium. In this

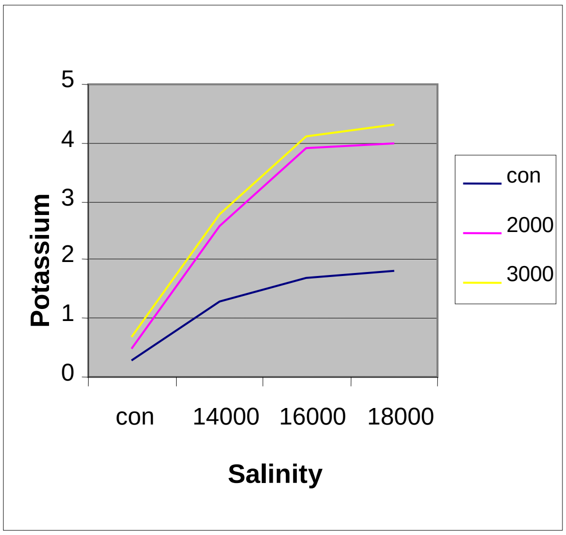

Fig. 1. Effect of potassium and salinity concentrations on proline content of leaves date palm

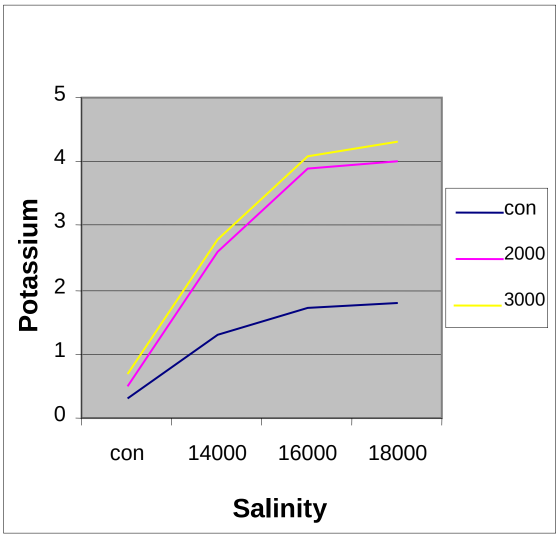

Fig. 2. Effect of potassium and salinity concentrations on leaves sodium contents of date palm

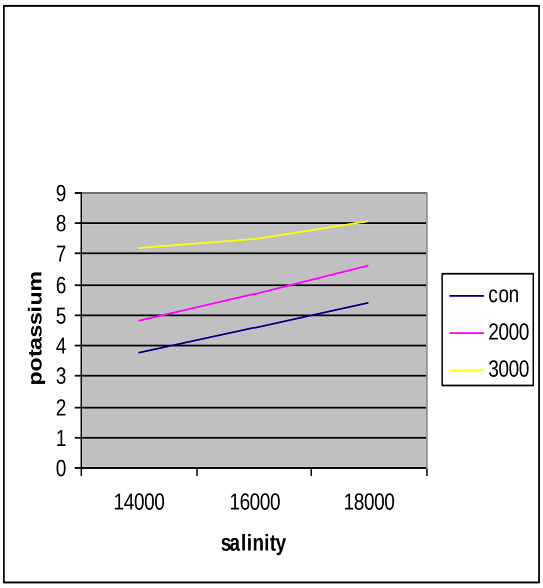

Fig. 3. Effect of potassium and salinity on calcium content of leaves date palm

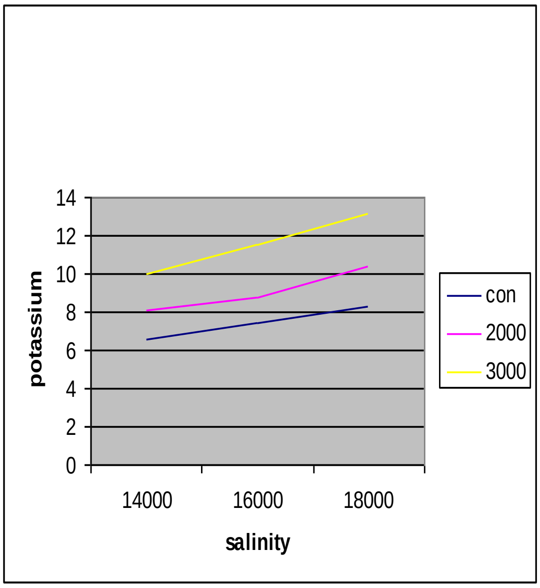

Fig. 4. Effect of potassium and salinity on content potassium of leaves date palm

Effect of potassium and salinity concentrations on proline mg/g, sodium, calcium and potassium (ppm d.w.) contents of leaves date palm at the first season

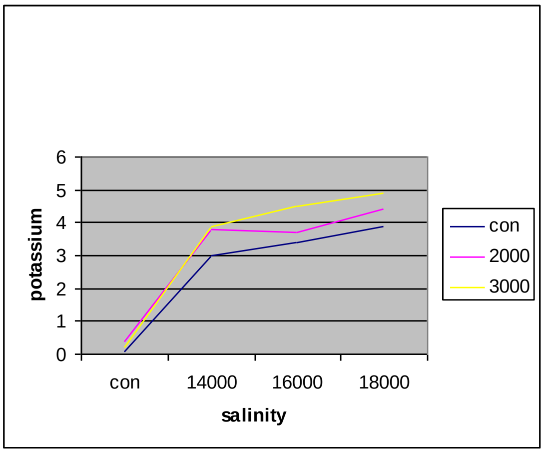

Fig. 5. Effect of potassium and salinity on proline content of leaves date palm

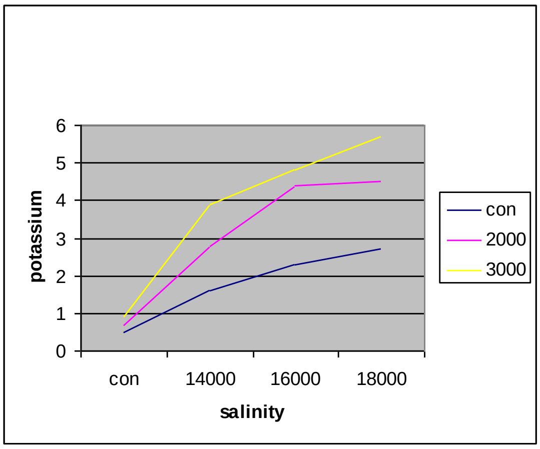

Fig. 6. Effect potassium and salinity on content of sodium (mg/g d.w) of leaves date palm

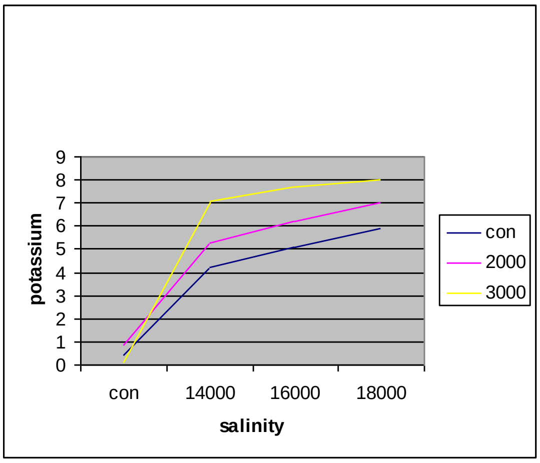

Fig. 7. Effect of potassium and salinity concentrations on content of calcium of leaves date palm

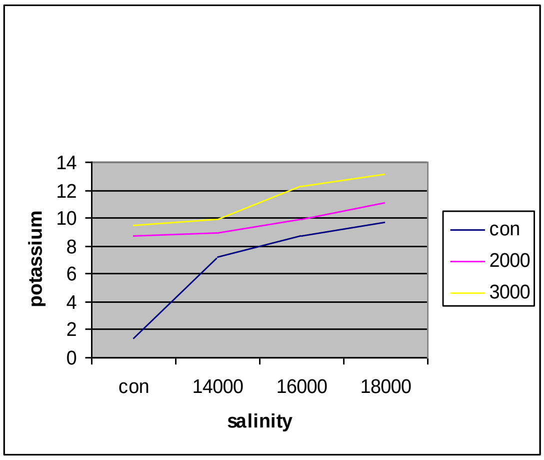

Fig. 8. Effect of potassium and salinity concentrations on potassium content of leaves date palm

Effect of potassium and salinity concentrations on contents of proline (mg/g d.w.), sodium, calcium and potassium (ppm d.w.) of leaves date palm at the second season

respect level 3000 ppm gave the highest significant result. Most significant interaction was obtained by the treatment 3000 ppm potassium with the level 18000 ppm of salinity. Soad (2005) on jojoba (*Simmondsia chinensis*), **Bahmaniar *et al* (2006)** on *Triticum aesitivum* L, **Mahmoud and Athar (2008)** on *Panicum turgidum* revealed that, Na and K were increased with increasing salinity (1.5- 6.0 ds/m) and stated that, Na :K ratio in older leaves appears to be a useful marker for salinity tolerance. The relative tolerance to salinity appeared to be due primarily to their ability to exclude Na from leaves.

From the obtained results it can be concluded that the plantlets of date palm which were produced by tissue culture can be tolerant to salt stress by addition of potassium which has high significant mitigation effects on the growth parameters of plantlets.

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