ION AND WATER RELATIONS OF DATE PALM TREES GROWN IN AL-HASSA COAST OF ARABIAN GULF OF SAUDI ARABIA

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ABSTRACT

This study was carried-out on date palm trees grown at Al-Ojair in the coast of Arabian Gulf during 1999/2000. Ion and water relations were investigated using trees of Khalas variety grown at Al-Hassa under field conditions as a control.

The result of ion relations revealed that high external EC in Al-Ojair resulted in greater internal Na^+ and Cl^- concentrations, compared with the non saline media which contributed to the decrease in leaf and root osmotic potentials. Concentration of macro nutrients represent levels regarding adequate for growth even under saline condition. All the trees show no reduction in chlorophyll content even under saline condition but chlorophyll content decreased as leaf aged. All date palm trees generated sufficiently larger water potential for import gradients of water with no significant differences in turger pressure.

INTRODUCTION

The prospect of greening the world’s coast with seawater tolerant plant has been the most cited scenario. So far, seawater agriculture has been found to work well in the sandy soil (Glenn and O’Leary, 1999). A limitation of the use of seawater is the low salt tolerance of the conventional crops (Wescott, 1988 and Rhoades et al,1989). Since date palm trees have been reported to tolerate higher level of salinity, it can be considered as a one candidate to be used under seawater irrigation (Bernstein, 1961; Furr et al, 1966; Hussein et al, 1996 and Hassan and AlSamnoudi , 1996).

Little information is available regarding ions partitioning, translocation and cycling of date palm under saline condition.

The delivery of ions to a leaf is a function of the salt concentration in the xylem water and the transpiration rate of that leaf (Flowers, 1985). The final ion concentrations of a leaf are the balance between import via the xylem and phloem, and export in the phloem (Pitman and Cram, 1977). Gorham *et al* . (1985) in their review concluded the most evidence suggests that Na^+ and Cl^- are relatively immobile in the phloem. However, Na^+ mobility in phloem is generally higher in species of low than of high salt-tolerance (Jeschke *et al* , 1986). *Ricinus communis* (Jeschke and Pate, 1991) and *Panksia prionotes* ((Jeschke and Pate, 1995) appeared to show greater Na^+ in the phloem than the salt tolerant *Aster tripolium* (Downing, 1980). Maintaining high concentrations of Na^+ and Cl^- in senescent leaves, raises the possibility that the essential nutrients were withdrawn from old leaves while Na^+ and Cl^- were left to be removed by leaf death. This helps senescence to play a relief mechanism to regulate Na^+ and Cl^- concentrations of leaves. The lower K^+ concentration with an increasing Na^+ supply could be attributed to the antagonism between Na^+ and K^+ which leads to decreased K^+ uptake (Salisbury and Ross, 1992). Jeschke and Pate (1991) found that flow pattern for Mg^{++} in *Ricinus communis* plants under salt stress, showed relatively even distribution through the plant but with extra uptake by young leaves and generally less export from than import into leaf laminae. The return flow of Mg^{++} from the shoot to root was considerably less than the recorded increment of the root (Marschner, 1995). Ca^+ is essential for the normal development of cell wall and membranes of cells. It is an immobile element within the plant, and, as a result deficiencies tend to appear in the expanding leaves. Ca^{++} partitioning studies shoed extremely poor phloem mobility, leading to progressive accumulation in leaf laminae and its cycling through leaves or roots is unlikely to be operative (Marschner, 1995 and Jeschke and Pate, 1995).

Maintaining a more negative shoot water potential than the external medium is how the plant sustains a water potential gradient which assure the inward flow of water in diverse saline environments. Most research dealing with effects of salinity on water relations assumes the general theory that Na^+ and Cl^- are the predominant inorganic ions which are sequestered in vacuoles while compatible organic solutes (e.g. betaine) are synthesized as a means of balancing the water potentials between plant and media. These inorganic solutes mainly contribute to osmotic adjustment and consequently turgor maintenance (Munns et al., 1983 and Flowers and Yeo, 1986).

The aim of this study is to give more fully understanding of the quantity pattern of ion uptake, flow and utilization in date palm grown under saline condition at leaves and whole plant level.

MATERIALS AND METHODS

Trees of date palm (Phoenix dactylifera, L.) growing in open mixed date palm trees on deep sandy soil in Al-Ogair coast, 120 km from Al-Hassa were chosen for this study. The study was carried out during spring 1999. Four uniform, 20 years old palm tree were selected from the mixed population. Trees from the farm in the oasis were included as control. Electrical conductivity (EC) and pH of the saturation paste of the soil in both sites was determined and found to be as shown in Table (1). Leaves of the trees were designated into the following five categories (Fig. 1):

1- Expanding leaves (L_1).
2- Recently expanded leaves (L_2).
3- Fully expanded leaves (L_3).
4- Mature fully expanded leaves (L_4).
5- Senescent leaves (L_5).

Leaves samples were taken from the mid of leaves and washed twice in distilled water. The plant sample after drying at 80^{o} C for 48 hours were ground and kept in glass containers for ion analysis.

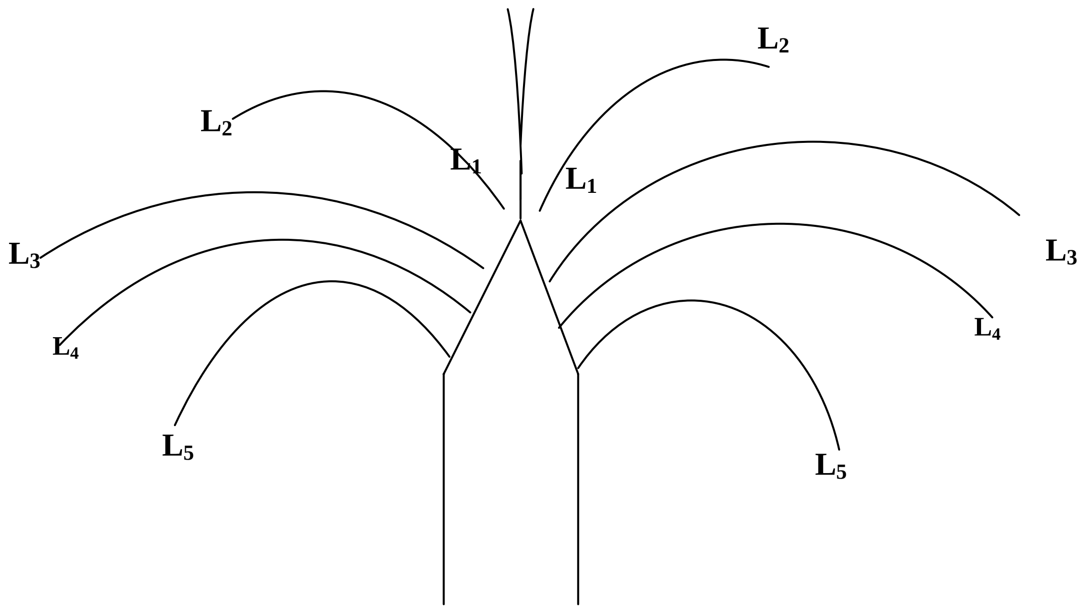


Fig. (1): Diagram appearing leaf position as growth stage on the stem of date palm tree.

Ion analysis:

Plant dry matter was extracted with nitric acid and the resulting extracts analyzed for macro and micro nutrients by atomic absorption spectroscopy or extracted with boiling water for Cl^- determination by chloridmeter. Nitrogen was determined using Kjeldahl apparatus. Phosphorus was determined by the molybdenum blue methods.

Water relations

Leaf and root water and osmotic potentials were measured with Wescar HR-33T dew point Microvoltmeter equipped with C52 sample chambers. Water potentials were determined after 1 hour equilibrium time at 22±1°C. After measurements were taken, the leaf disks were removed wrapped in aluminum foil and dipped into liquid nitrogen. They were then thawed, unwrapped and returned to the chamber for measurements of leaf osmotic potential after 30 min equilibration time. Reading for water and osmotic potentials were made after a 10 second cooling period. Water potential of the soil solution was determined in the extract of the saturation paste using the osmometer .

Table (1): Soil electrical conductivity of the study sites.

Location	**Al-Hassa Oasis**	**Al-Ogir**
Depth		
0 - 30 cm	**2.3**	**24.3**
30 – 60 cm	**5.0**	**16.1**

RESULTS

Na^+ concentration in expanding L_1, and fully expanded L_3 leaves were higher under saline condition, compared with recently expanded (L_2), mature fully expanded (L_4) and senescent leaves. L_5 had significantly higher Na^+ concentration, compared with other leaf categories which green leaves confirmed almost constant concentration of Na^+ .

K^+ concentration in L_1 and L_3 was higher in saline condition, compared with $L_{2,}$ L_4 and L_5. K^+ concentration was significantly lower in L_4, compared with other leaf categories, which L_2 and L_3 had relatively higher K^+ concentration in.

Ca^{++} concentration L_1, L_3 and L_5 leaves were higher under saline condition. L_4 and L_5 had significantly higher Ca^{++} concentration under both saline and non-saline conditions. Ca^{++} concentration in L_4 and L_5 was exceeding two told the concentration in L_1 in its correspond condition. There was a significant trend of increasing Ca^{++} concentration as leaf aged. This trend was evident in both saline and non-saline conditions.

Cl^- concentration in L_1, L_2 and L_3 was significantly higher under saline condition. There was a significant trend of increasing Cl^- concentration as leaf aged. This trend was evident in both saline and non-saline conditions. L_5 had significantly substantial Cl^- concentration exceeding four and two told the concentration in L1 under non-saline and saline conditions, respectively.

Mg^{++} concentration was higher under saline condition and this evident was significant in L_1. L_1 had significantly the lowest Mg^{++} concentration, compared with other leaf categories under both saline and non-saline conditions. L_5 had the highest Mg^{++} concentration. There was a trend of increasing Mg^{++} concentration as leaf aged.

There was no significant difference observed in chlorophyll content between saline and non-saline conditions. L_1 had significantly the lowest chlorophyll content with almost negligible content. Chlorophyll content was significantly increased as leaf aged until L_3 when a reduction was appeared. Beyond L_4 a sharp reduction in chlorophyll content was observed as leaf died. This trend was similar in both saline and non-saline conditions.

Leaf water potentials were substantially more negative than the osmotic potential of the media solution of saturation paste, thus establishing gradient for water import. Expanding leaves (L_1) had more negative leaf water potentials by about 0.2 and 0.35 MPa than fully expanded leaves (L3) for saline and non saline media, respectively. This figure also demonstrate the much smaller gradient between the root and leaf water potentials under saline condition and their media, compared with non saline condition. This indicates that there was a decrease in water potential from media via root to expanding leaves (L1). This gradient was more pronounced under non-saline condition.

Exposure to salinity did not result in any significant difference in turger in each leaf category which indicates each leaf category, maintained relatively constant turgor pressure despite the large differences observed in their osmotic potentials. In this way, the leaves were able to develop increasingly negative leaf water potential as the osmotic potential changed.

DISCUSSION

Obtained results of this study indicate an increase in Na^+ , K^+, Ca^{++}, Mg^{++} and Cl^- concentration in L_1 and L_3 under saline condition which reflects an increase in xylem ion concentration. This increase in xylem ion concentration may then lead to the higher concentration of these ions in leaf tissues which may contribute to decreasing the leaf osmotic potential of these leaf categories. However, green leaves ($L_{1,}$ L_2, L_3 and L_4) had significantly lower Na^+ and Cl^- concentration which suggest a mechanism exclude mainly Na^+ and Cl^- from these leaves and its retention in senescence leaves. This indicates that senescence plays a relief mechanism to regulate Na^+ and Cl^- concentration of leaves

The higher K^+ concentration in recently expanded leaves L_2 and fully expanded L_3 could be due to the faster rate of transpiration of this leaf which reflects the active status of this leaf category.

The lower ion concentration in expanding leaves suggest that ions may not provide adequate solute for osmotic adjustment in this leaf category. Gorham *et al* (1985) reported that under saline condition, Na^+ and Cl^- increased in the leaves contributed to osmotic adjustment but were accumulated mainly in the vacuole when tissue concentration exceeded about 200 mol/m^3 water volume (i.e. osmotic pressure greater than 0.9 Mpa). The analysis in the present study shows that Na^+ concentrations in date palm leaves were much in excess of this value of

200 mol/m^3 in the tissue water volume in both saline and non-saline condition.

A more negative root and shoot water potentials than found in the external media is necessary for the plant to sustain a water potential gradient which assures an inward flow of water in diverse saline environments. The results of the present study indicate that root and leaf water potentials and osmotic potentials were generally more negative under saline condition, increasingly so in expanding leaves.

The K^+, Ca^{++} and Mg^+ concentrations of leaf tissues in the present study of plants grown even under saline condition, represent levels usually regarded as adequate for growth (Taiz and Zeiger, 1991 and Salisburg and Ross, 1992).

Ca^{++} is essential for the normal development of cell wall and membrane of cells. It is immobile element within the plant and as a results deficiency tend to appear in the expanding leaves. No Ca^{++} deficiency symptoms appeared in this study. Ca^{++} and Cl^- partitioning studies showed extremely poor phloem mobility in leaf laminae and there cycling through leaves or roots is unlikely to be operative (Marschner, 1995; Jeschlce and Pate, 1995)which is in agreement with the results of the present study.

Mg^{++} concentration in L_1 was significantly lower and was also supported by the neglictaise chlorophyll content in this leaf category. This indicates that expanding leaves (L_1) of date palm does not play any role in assimilate production. Jeschke and Pate (1991) found that flow pattern for Mg^{++} in *Ricinum communis* plants under salt stress showed relatively even distribution through the plant, but with extra uptake by young leaves and generally less export from than import into leaf tissue. This results contract with what have been reported in the present study.

Salinity in the present study had no effect on chlorophyll content. Guy and Read (1986), Everard *et al* (1994) also reported similar results. The changes in chlorophyll contents observed here are consist with what was reported in Mg^{++} that chlorophyll content increased with leaf age until L_4.

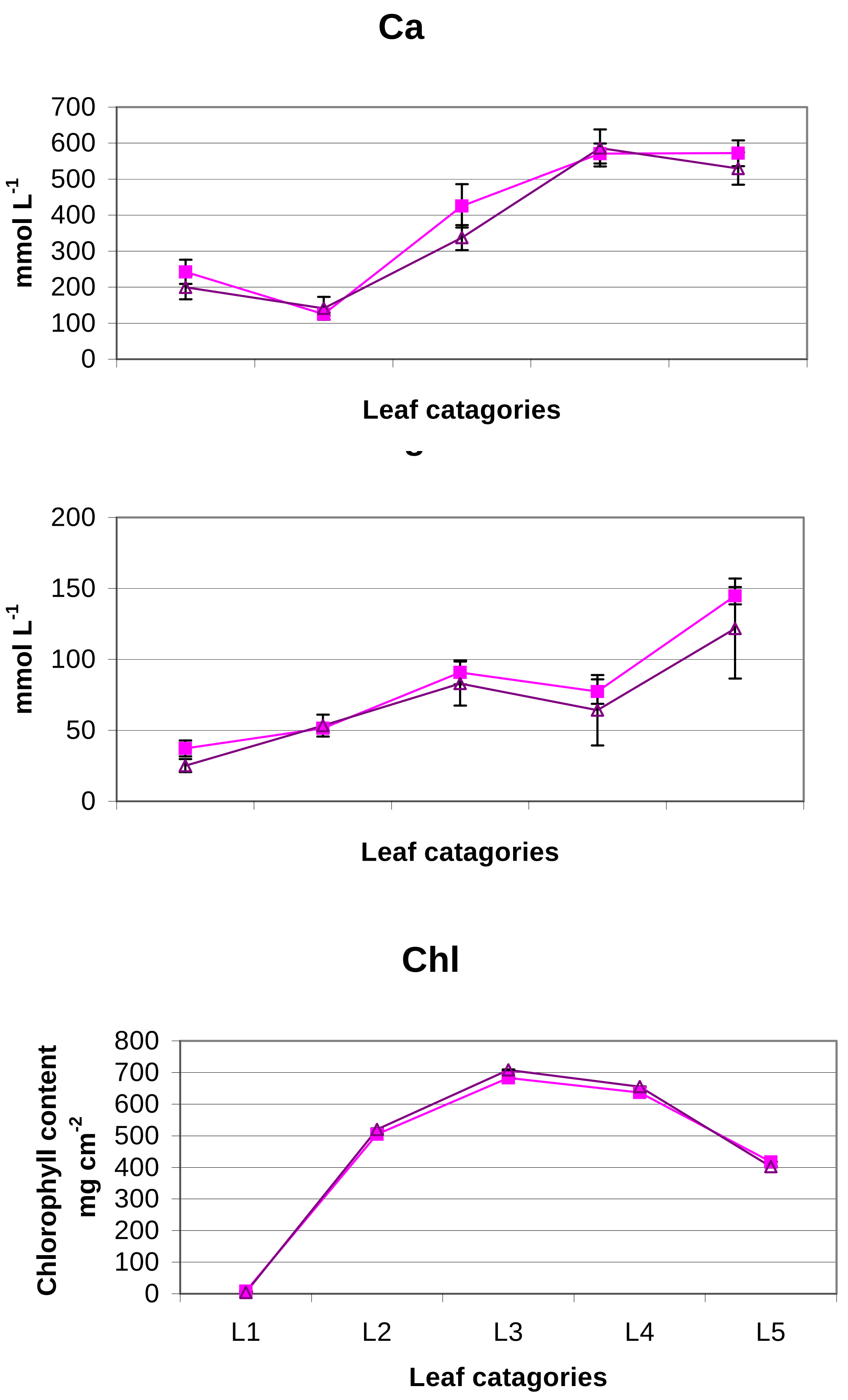
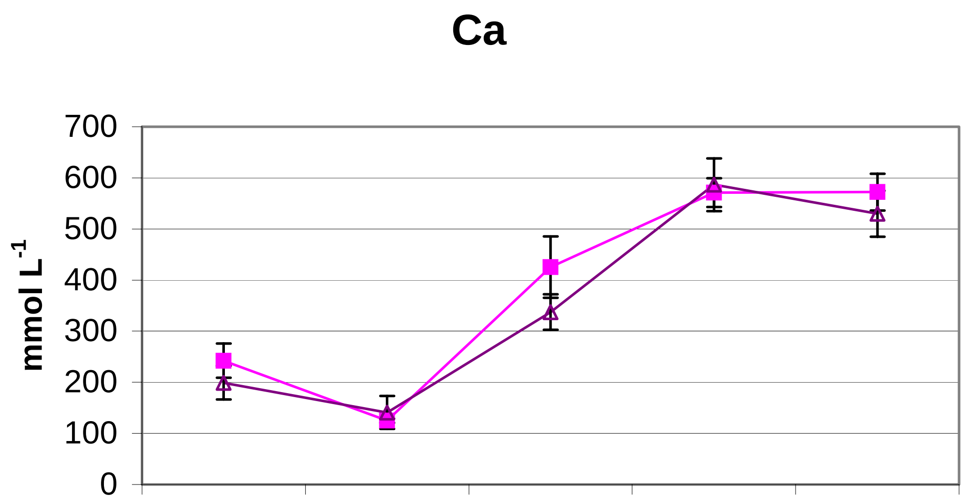
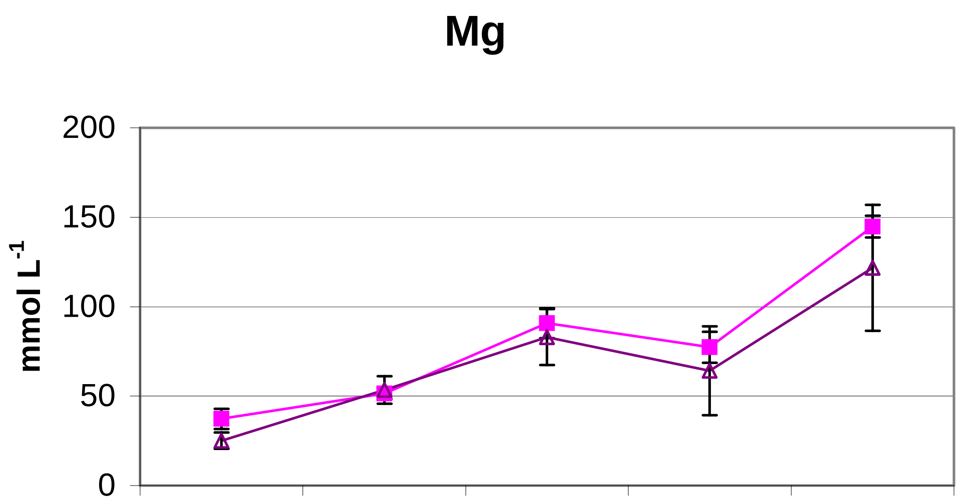
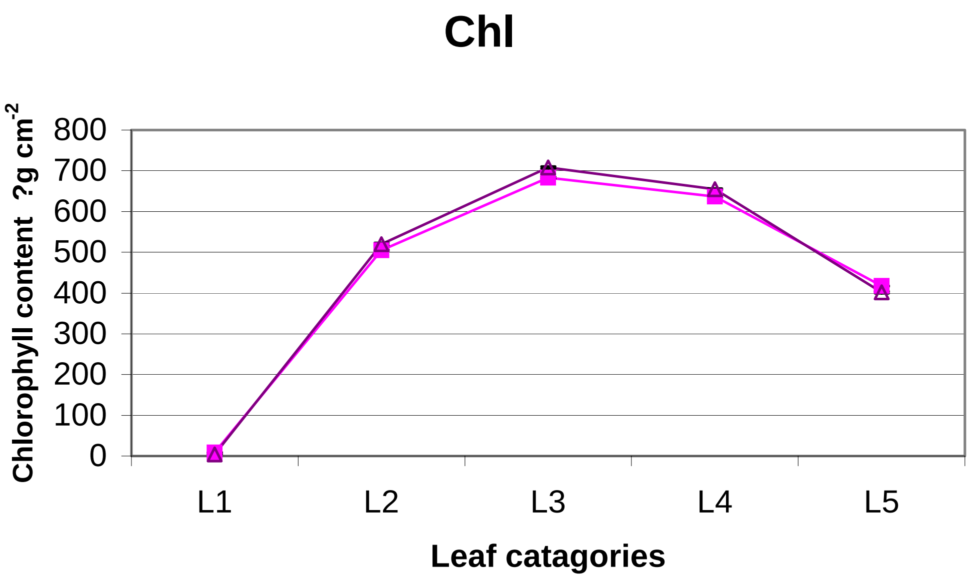


Fig. (3): Contents of nitrogen (N), Phosphorus (P), Magnesium (Mg) and chlorophyll (Chl) in leaves of date palm grown in saline (□) o non-saline (△) conditions. Error bars represent SE values and are smaller than the symbol if not shown.


Ca
700
600
500
400
300
200
100
0
mmol L-1


Mg
200
150
100
50
0
mmol L-1


Chl
800
700
600
500
400
300
200
100
0
Chlorophyll content ?g cm-2
L1
L2
L3
L4
L5
Leaf catagories

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