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Effects of salt stress on ion accumulation in root and shoot of *Alhagi persarum*

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Abstract. Todays, salinity were became the most important challenges for agriculture. To understand aspects of the salt tolerance halophyte plants is important to help solve the problem of salinity in agricultural and horticultural soils. In this study we try to understand the role of root and shoot of *Alhagi persarum* in ion accumulation under salinity stress. Seeds of *A. persarum* were planted and salinity treatments (0 (control), 100, 200, 300, 400, 500 mM of NaCl and Na_2SO_4 separately) were applied in 45 days. Na^+, k^+, Mg^{2+} and Ca^{2+} were measured in root and shoot. ANOVA results showed that salt type did not affect significantly ion content in plant, but accumulation of ions in different plant part, except of Na^+, show significant difference. Duncan test showed that Ca^{2+} accumulated in root of *A. persarum* more than shoot. But, Mg^{2+} and K^+ were higher in shoot. Na^+/K^+ and Na^+/Ca^{2+} ratios increased with salinity increasing. In summarize, *A. persarum* tolerates salinity with distribution of different ions in the root and shoot.

Key words: salinity, root, shoot, ion content, *Alhagi persarum*

1. Introduction

Mechanisms of plants to tolerate salinity have been intensively studied in the last decades. Most of these studies have been focused on ion content, water relations, osmolytes synthesis such as proline, betaien, carbohydrates and changes of growth indices in plant (Bohnert et al. 1995; Cicek and Cakırlar, 2008; Duan et al.2007; Gama et al. 2007). Scientists believe that, plant tolerate salinity with increasing Na^+ and Cl^-, decreasing K^+, Mg^{2+}, Ca^{2+} and P^+, accumulate of osmolytes in different organs, increasing Osmotic Potential and Water Use Efficiency and changes in Relative Water Capacity(Song et al. 2005; Zobayed et al. 2006; Gramer, 2002). One of the other things that is well known and which is one of the enigmas in salinity research, is that, although the first organ of the plant that is exposed to salinity is the root system. However, we have very little data about the role of each part of plant in salinity tolerance (Khan et al. 2006). In fact, root, shoot and leaf have different responsibilities and operate particularly. In this study we try to understand the role of root and shoot of *Alhagi persarum* in ion accumulation under salinity stress.

2. Materials and Methods

Alhagi persarum Boiss & Buhse (camel thorn) is a valuable semi shrub and widely adapted to divers environment of Iran. Seeds of *A. persarum* were collected and planted in Plastic pods with the Silica sand bed. Plants were nitrified with Hoagland's nutrient solution for 6 months (Hoagland and Arnon, 1950). Then, Salinity treatment consisted of 0 (control), 100, 200, 300, 400, 500 mM of NaCl and Na_2SO_4 separately, were applied in 45 days. Na^+, k^+, Mg^{2+} and Ca^{2+} were analyzed using an inductively coupled

plasma atomic emission spectrometer (ICP) (Navarro et al. 2006) in root and shoot of plant. Ratio of ions and shoot/root calculated. A one way ANOVA with factorial scheme was carried out to determine

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differences among treatments with SPSS 17.0. Significant differences between means were determined using Duncan test.

3. Results

A one way ANOVA showed that salt type did not affected significantly ion content and shoot/root ratio in plant, except of K^+. But accumulation of ions in different plant part, except of Na^+, show significant difference. Salt concentration had significant effect at all studied factors (table1).

Table1. ANOVA Results of ion changes in A. persarum organs

Dependent Variable / Sources	Ca^{2+}	Mg^{2+}	K^+	Na^+
Salt type	0.057^{ns}	0.496^{ns}	8.351^{**}	0.049^{ns}
Plant part	376.47^{**}	37.56^{**}	389.38^{**}	3.314^{ns}
Salt concentration	5.203^{**}	10.43^{**}	25.314^{**}	19.22^{**}
Dependent Variable / Sources	Ca^{2+} (shoot/root)	Mg^{2+} (shoot/root)	K^+ (shoot/root)	Na^+ (shoot/root)
Salt type	0.332^{ns}	0.121^{ns}	0.2^{ns}	0.202^{ns}
Salt concentration	4.37^{**}	3.4^{*}	5.38^{**}	14.17^{**}
Dependent Variable / Sources	Na^+/K^+	Mg^{2+}/Ca^{2+}	Ca^{2+}/K^+	$Na^+/Ca2^+$
Salt type	0.657^{ns}	0.138^{ns}	0.413^{ns}	1.2^{ns}
Plant part	89.46^{**}	604.3^{**}	82.31^{**}	275.4^{**}
Salt concentration	18.04^{**}	3.45^{*}	3.13^{*}	14.44^{**}

- Numbers shows F value , * $p < 0.05$, ** $p< 0.01$, ^{ns} non significant

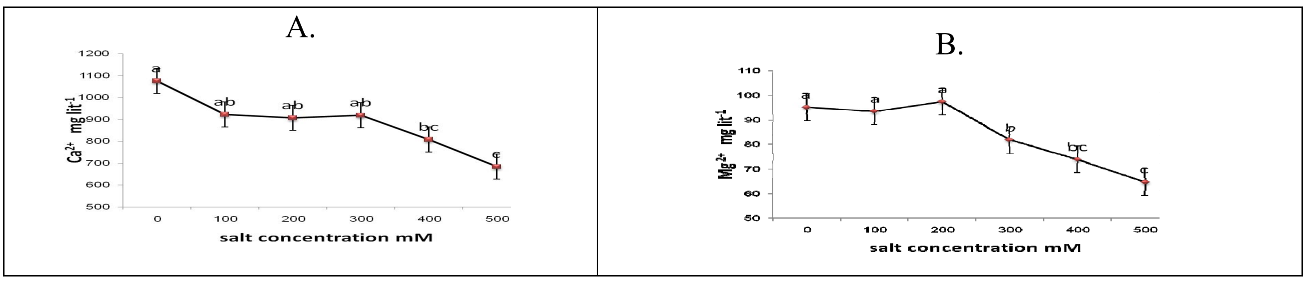
Comparison of ions at different plant organs with Duncan test showed that the root contained more Ca than shoot. But, Mg and K were more in shoot. Also, K was more at Na_2SO_4 (table 2 and figure 3).

Table 2. Results of Duncan test in different plant organs and salt type

Dependent Variable	Plant part	Mean	Salt type	Mean	Dependent Variable	Plant part	Mean	Salt type	Mean
Ca^{2+}	shoot	430.74 b*	NaCl	891.632 a	K^+	shoot	533.42 a	NaCl	364.735 b
	root	1341 a	Na_2SO_4	880.412 a		root	239.14 b	Na_2SO_4	407.832 a
Mg^{2+}	shoot	94.687 a	NaCl	83.247 a	Na^+	shoot	960.34 a	NaCl	905.204 a
	root	74.167 b	Na_2SO_4	85.607 a		root	862.06 a	Na_2SO_4	917.208 a

*: Letters indicate significant differences between treatments

Duncan test indicated that Mg^{2+}, Ca^{2+} and K^+ contents decreased with salinity increasing at all treatments(fig. 1-A,B,C and fig. 3-A,B,C). But, the concentration of Na^+ ions of *A. persarum* was also influenced by salinity treatments, with seedlings exposed to greater salinity generally displaying a greater concentration of Na^+ in the plant. Na^+ content increased in up to 200-300 mM. But it decreased with a further increase in salinity (fig. 1-D and fig. 3-D). Fig. 2 shows that shoot/root ratio of Mg^{2+}, K^+ and Na^+ decreased in up to 100 mM and increased with more increasing salt concentration. Figure 2.A indicates that Ca^{2+} decreased in shoot less than root in up to 200 mM and then it became inverse. Also, Ca^{2+} content in shoot is less than root at all salt concentrations whilst Mg^{2+}, K^+ and Na^+ in shoot are more than root (fig. 2).



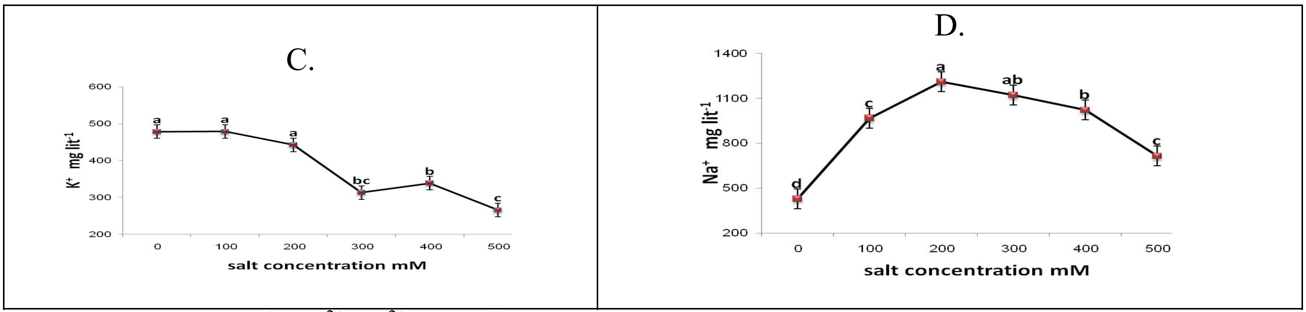


Fig.1: Duncan test of K^+, Mg^{2+}, Ca^{2+} and Na^+ at different salinity concentrations. Bars represent mean ± standard error. Different letters represent a significant difference $P < 0.05$ between treatments.

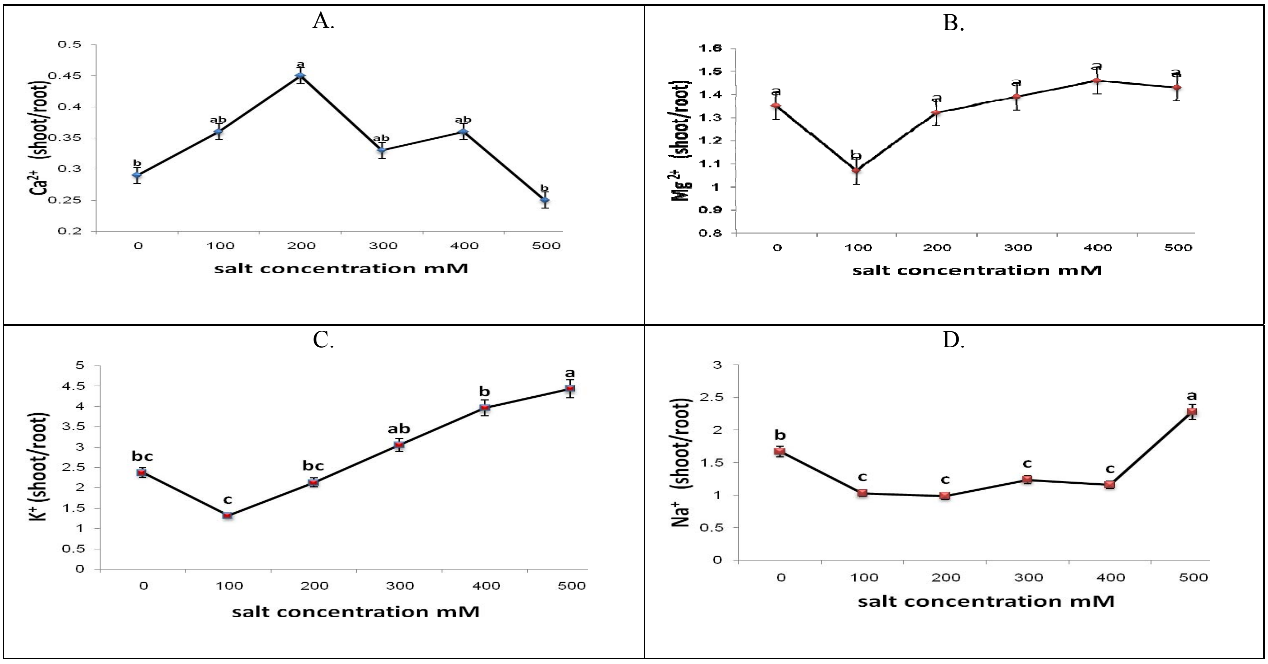
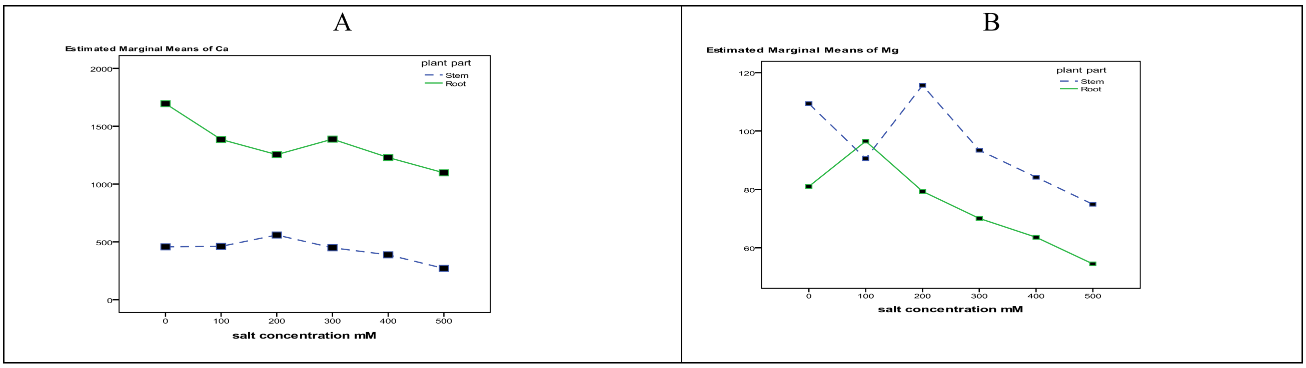


Fig. 2: Duncan test of shoot/root ions ratio at different salinity concentrations. Bars represent mean ± standard error. Different letters represent a significant difference $P < 0.05$ between treatments.

Moreover, Figure 3 indicated that changes trend was not coincided in root and shoot, especially at low salinity. The root content of K^+ and Mg^{2+} tended to increase, while its shoot content tended to decrease. There was relatively small reduction in stem Ca^{2+} in comparison to the very large reduction of root.



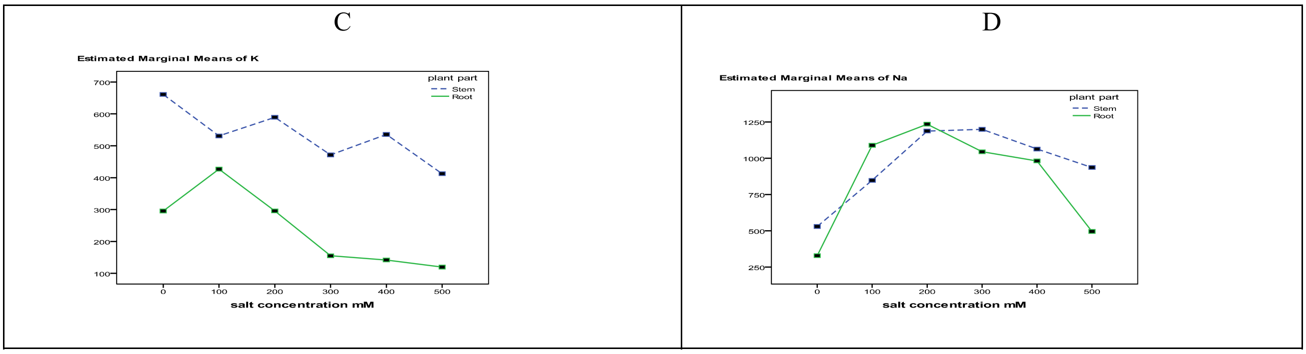


Fig. 3: estimated marginal means of ions at different salt concentration and plant parts.

Fiurge 4.A and B indicate that Na^{+}/K^{+} and Na^{+}/Ca^{2+} ratio increased with salinity increasing in shoot and root of *A. persarum*. But they decreased at high salinity in root. Na^{+} increasing simultanouses with K^{+} and Ca^{2+} decreasing. In addition, Ca^{2+}/K^{+} ratio decreaed at low salinity in root and then incresead. Ca^{2+} and K^{+} changed in shoot, similarly and Ca^{2+}/K^{+} ratio did not vary significantly in shoot with salinity increseaing.

Mg^{2+}/Ca^{2+} ratio decreased at moderate salinity in shoot whilst it increased in root. It did not vary significantly at control and high salinity in root and shoot.

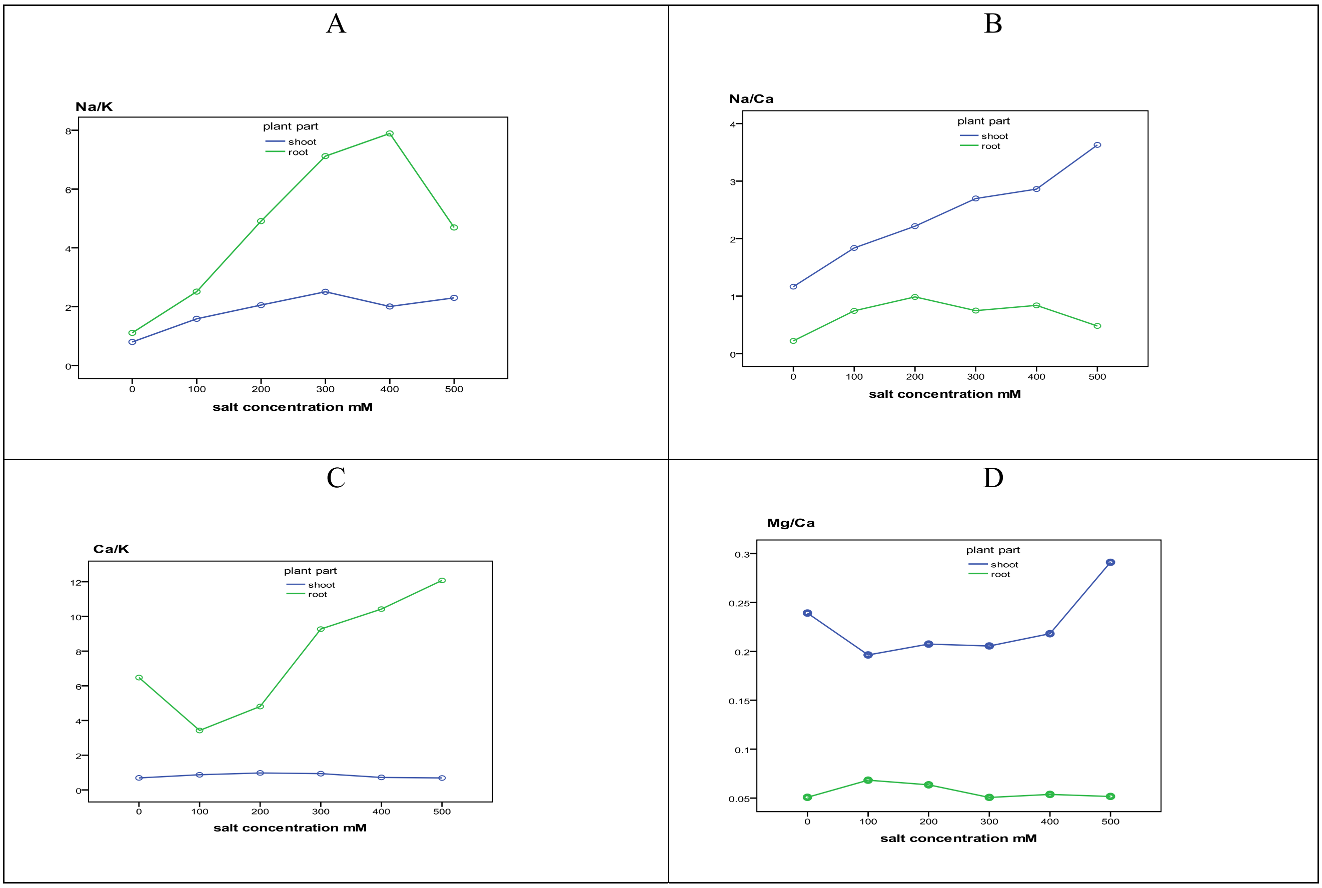


Fig. 4: ions ratio changes at different salt concentrations and in different plant organs.

4. Conclusion

According to our results, ions accumulation in *A. persarum* was influenced by salt concentrations and plant organs, whilst salt type did not affect ion content. *A. persarum* uptakes Na^{+} in saline environments and repulses K^{+}, Ca^{2+}, Mg^{2+}. El-Fouly *et al*. (2004) in tomato, Kurban (2005) in *alhagi pseudoalhagi* and Arndt et al. (2004) found that Na^{+} and Cl^{-} uptake markedly increased with increasing NaCl growth medium. Khan et al. (2006) reported that K^{+} and Mg^{2+} decreased with salinity increasing in alfa alfa. This study showed that Ca^{2+} decreased in shoot more than root at high salinity. Cramer et al. (1990) and Khan et al. (1998) indicated that decrease of Ca^{2+} in aboveground organs is an important indicator of salinity stress.

Jie et al. (2008) indicated that the halophyte plants accumulated more Na^+ and Cl^- in aboveground tissues compared to roots. Kurkova et al. (2002), also, showed that the contents of Na^+ and K^+ increased in the root tissues at low salinity and the contents of sucrose, proline, and betaines decreased as compared. They said that halophyte plants are capable of withstanding abrupt salt stress, due to the shift of osmoregulatory systems (ionic and organic) and isolation of the excess of salinating ions by their accumulation in the central vacuole through pinocytosis, as well as in small cytoplasmic vacuoles. Therefore, it can be suggested that pinocytosis and small cytoplasmic vacuoles were extended in shoots more than roots, when the plant exposed to salinity. Increasing of Na^+/K^+ and Na^+/Ca^{2+} ratio can be related to selective absorption of cell membrane and salinity tolerance. It has been reported by Gorham (1997). Ca^{2+}/K^+ and Mg^{2+}/Ca^+ ratio indicated that there is competition among Ca^{2+}, Mg^{2+} and K^+ absorption in plant. Also, Ca^{2+}/K^+ ratio in shoot and Mg^{2+}/Ca^{2+} ratio in root of A.persarum show cooperation relation between them. These agree with Belda and Ho (1993) and Robert and Susan (2004). In general, the most changes of ions in different plant organs of *A. persarum* and salt concentration occur at 100-300 mM of salinity. It confirms that it is a moderate halophyte.

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