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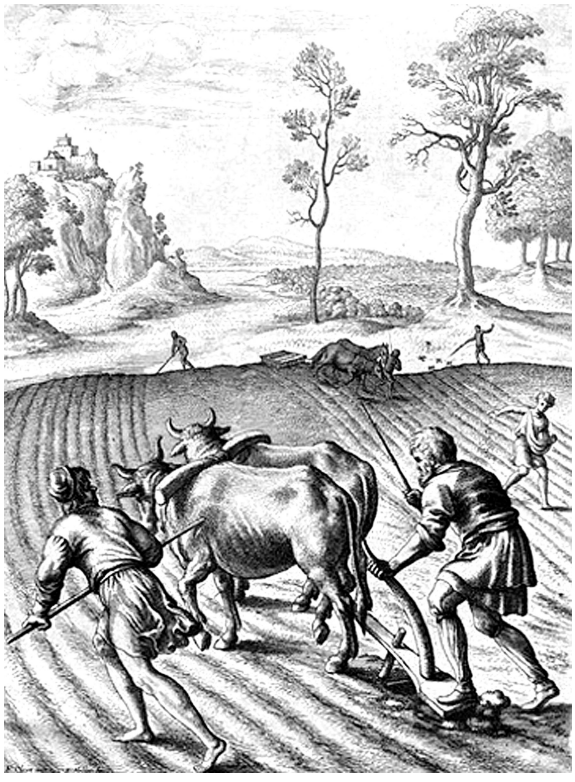

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Effect of Salinity on Growth of Five Natural Populations of *Atriplex halimus* L. in Morocco

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Abstract: Growth of the *Atriplex halimus* L. were measured to compare the effects of 0, 150, 300 and 450 mM NaCl, KCl, Na_2SO_4 or K_2SO_4. Plant height, number of leaves, fresh mass and dry mass were measured. The results showed differences in plant growth responses according to K^+ and Na^+ salts. In general, K^+ salts exhibited higher inhibition to growth than Na^+ salts. Another goal of this study is a comparison the response of NaCl salt at five Moroccan populations. The result indicated the existence of a highly significant variability between populations. At each concentration, population SB that comes from a locality by the Atlantic Ocean, showed the mildest effect of salinity. In contrast, the strongest inhibitory effect on growth was observed in population SE originated from a continental site.

Key words: *Atriplex halimus*, natural populations, growth, salt stress

INTRODUCTION

Atriplex constitutes an essentially cosmopolitan genus of more than 417 species (Osmond *et al*., 1980). *Atriplex* species (saltbushes) are dominant in many arid and semi-arid regions of the world (McArthur and Sanderson, 1984). Most of the species are known for their high tolerance to aridity and salinity (Le Houerou, 2000; Stringi *et al*., 1994). Many species of the genus *Atriplex* are excellent livestock because of their favourable crude protein content (McKell, 1994).

Atriplex halimus is a perennial native shrub of the Mediterranean Basin with an excellent tolerance to drought and salinity (Ortiz-dorda *et al*., 2005). This species is valued as livestock forage when herbage availability is low (Le Houreou, 1992). Endowed with an important aerial biomass and a complex root system, the species represent an efficient and relatively non-expensive tool in the rehabilitation of degraded lands and in fighting against desertification (Abbad *et al*., 2004; Wills *et al*., 1999). The description and the conservation of *Atriplex halimus* genetic resources are particularly important for the rehabilitation of disturbed areas by salt and low rainfall.

Earlier study analysing the morphological and isoenzyme, showed high genetic diversity in nine Moroccan populations of *A. halimus* L. (Haddioui and Baaziz, 1999; Haddioui and Baaziz, 2001). In another study, the effect of NaCl on seed germination of five Moroccan populations of *A. halimus* show that germination and early seedling growth were variable between populations (Haddioui and Baaziz, 2006). To further characterise Moroccan populations of *A. halimus* L., the effect of salinity was assayed on plant growth. The occurrence of halophytes in soils may depend on their tolerance to salt stress at different stages of development (Adam *et al*., 1992). Several factors may contribute to a reduction in germination and growth exhibited by plants under salinity stress, such as osmotic potential or ion toxicity (Zhao and Harris, 1992).

In order to get an overview on the tolerance of *A. halimus* L. to salt stress, the effect of NaCl was assayed on plant growth of five Moroccan populations and the effect of various salts (NaCl, KCl, Na_2SO_4 and K_2SO_4) was assayed on plant growth of one population (Marrakech). Studying the effects of both chloride and sulfate salts on halophyte growth is important because these ions are the most common in salinized soils (Mor and Manchanda, 1992; Todd and Ungar, 1997).

MATERIALS AND METHODS

Seeds of *Atriplex halimus* L. were collected in November 1998 from five natural populations located in different environments (Table 1).

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Seeds were placed in Petri dishes for germination on a wet filter paper at 21°C as a constant temperature and a 12 h photoperiod. Five days after germination, the plants were placed into plastic pots containing soil (50% sand and 50% clay). Plants were allowed to grow for 15 days under natural conditions. Plants of population Marrakech were acclimatized to 0, 150, 300 and 450 mM concentrations of each NaCl, KCl, Na_2SO_4 and K_2SO_4. In another experiment, plants of the five populations were acclimatized to 0, 150, 300 and 450 mM of NaCl. There were ten replicates of each of the treatments and these were randomized weekly. Each pot was treated with one of the following concentrations of salt in half Hoagland's solution. At the initiation of the experiment salinity concentrations were gradually increased by 150 mM at 2 days intervals until required concentrations were reached. Plants were harvested after 4 weeks and plant height, number of leaves, fresh mass and dry mass were determined. Dry mass was determined after oven drying at 80°C during 48 h.

The data were subject to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Impact of salt types on plant growth in *Atriplex halimus* L.: The analyses of variance have shown significant difference due to salt type (plant height: F = 11.67; number of leaves: F = 2.92; fresh mass: F = 5.44; dry mass: F = 5.47; all $p<0.05$) and salt concentration (plant height: F = 160.55; number of leaves: F = 57.2; fresh mass: F = 92.33; dry mass: F = 48.89; all p = 0.05). At all concentration, plants grown in KCl and K_2SO_4 were significantly shorter than plants grown in NaCl and

Table 1: Populations of *Atriplex halimus* L. used in this study and their principal geographic and ecological characteristics

Population	Geographic origin	Latitude north	Longitude west	Altitude (m)	Rainfall (mm)
SB	10 km N of Safi	32°24'	9°14'	15	365
MA	5 km N of Marrakech	31°41'	8°00'	460	225
KL	El Kelaâ des Sraghna city	33°50'	4°37'	450	250
SE	20 km S of Settat	32°57'	7°40'	190	260
RA	Rabat city	34°03'	6°46'	65	540

SB = Sidi Bouzid; MA = Marrakech; KL: = El Kelaâ des Sraghna; SE = Settat; RA = Rabat

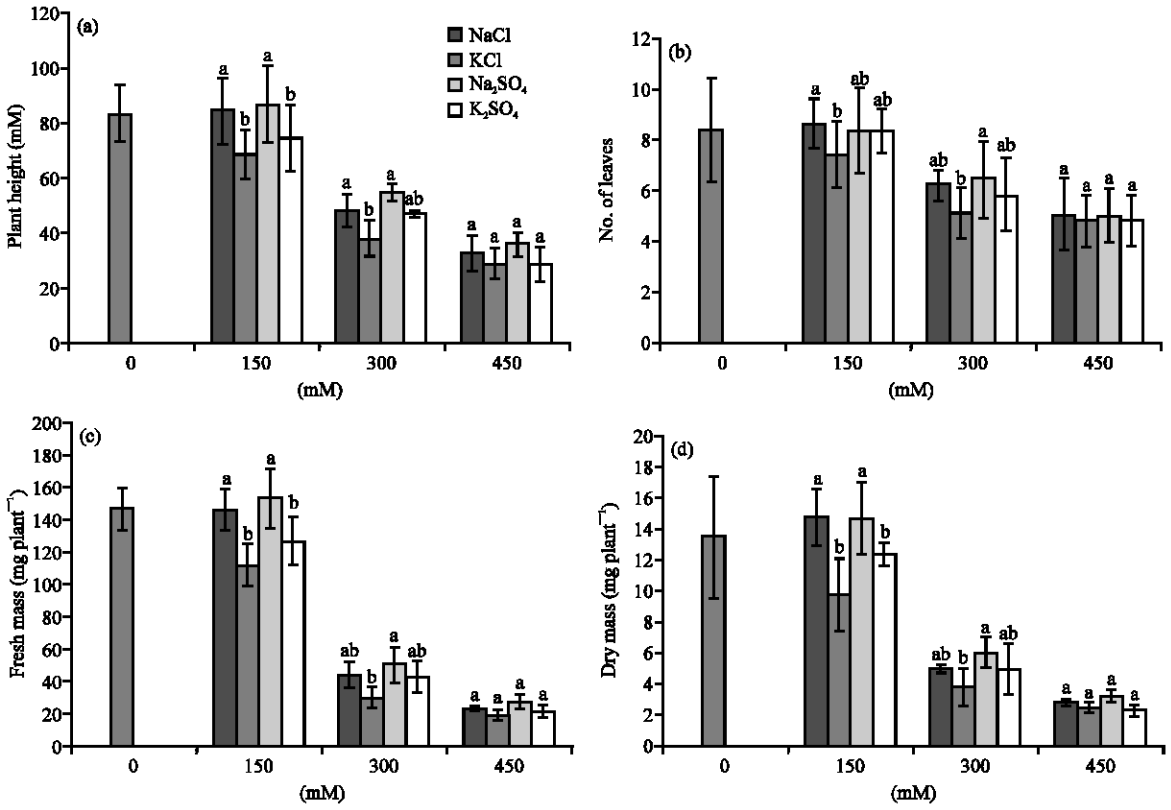

Fig. 1: Effect of NaCl, KCl, Na_2SO_4 and K_2SO_4 on the growth of Marrakech population, whole plants were exposed to 30 days of salt stress. Values represent means±SD, n = 10. The salts with the same characters are not different significantly at p = 0.05

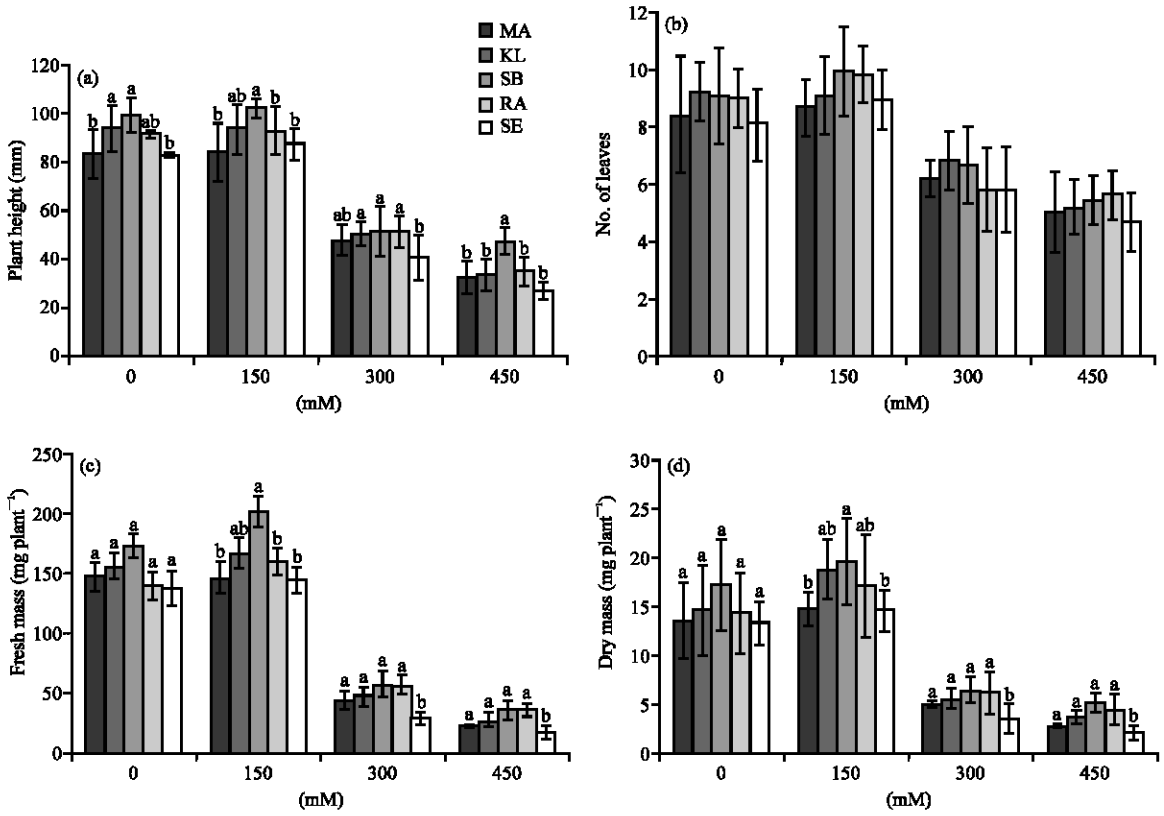

Fig. 2: Effect of NaCl salt on the growth of five populations, whole plants were exposed to 30 days of salt stress. Values represent means±SD, n = 10. The populations with the same characters are not different significantly at p = 0.05

Na_2SO_4. Plants grown in both K^+ salts had fewer leaves than plants grown in the Na^+ salts (Fig. 1). Plants treated with NaCl and Na_2SO_4 had the highest fresh mass of the other salt treatments. At all concentration, plant treated with NaCl and Na_2SO_4 had the highest dry mass compared to plants treated with KCl and K_2SO_4 salts. In general, the K^+salts was more inhibitory than Na^+. Similar results were previously reported in other studies for other species. Weimberg *et al*. (1984) found that KCl and K_2SO_4 were more inhibitory than NaCl and Na_2SO_4 on the growth of *Sorghum bicolor* (L.). At *Triticum turgidum* L. KCl salts was more inhibitory to growth than NaCl (Weimberg, 1988). Kefu *et al*. (1995) compared the effect of different salt on the halophytes *Sueda salsa* (L.), *Atriplex centralasiatica* and *Limonium bicolor*, they found that KCl had an overall more negative effect on plant growth. At *Atriplex prostrata*, Todd and Ungar (1998) demonstrated that K^+ salts of SO_4^- and Cl^- were more inhibitory to growth than Na^+ salts.

All salt types, the effect of salt on the growth of *Atriplex halimus* was most pronounced at the 300 mM. However, at 150 mM, growth parameters did not change significantly compared with plants treated with water. These results were reported for many species of the genus *Atriplex*. In general, low salinity levels do not appear to have a deleterious effect on the growth of plant (Ajmal Khan *et al*., 2000). However, high salinity levels may cause a reduction in total growth of *Atriplex* sp. (Ungar, 1996).

Comparison of natural populations of *Atriplex halimus* L. on their tolerance to NaCl: Analysis of variance indicated a highly significant difference among populations for three parameters (plant height: F = 14.06; fresh mass: F = 4.27; dry mass: F = 4.03; all $p<0.01$). For number of leaves, there were no significant differences between populations (F = 2.21; $p>0.05$). At all concentrations, population SB demonstrated greater height growth than other populations (Fig. 2). For fresh mass, plants of population SB had the highest fresh mass of any of the other populations at all treatments. However plants of population SE had the lowest fresh mass. For dry mass, population SB had higher dry mass than other population and population SE had significantly the lowest dry mass compared to other population. The result of this stage of development is the same of our previous germination experiment where it was determined that population SB is more tolerant to NaCl stress than the rest of populations

(Haddioui and Baaziz, 2006). This variability related mainly to the geographical origin of the used material may confirm the existence of polymorphism within the species. For all parameters, analysis of variance showed an overall significant difference due to salt concentration (plant height: F = 440.75; number of leaves: F = 128.6; fresh mass: F = 152.38; dry mass: F = 124.8; all p = 0.05). In all populations, plants grown in the high-salt treatment (300 and 450 mM of NaCl) had a significant reduction in growth parameters when compared with plants grown at water and lower salinity (150 mM of NaCl). This result indicates that growth was not inhibited by salinity of the 150 mM. However, in our previous experiment the same concentration (150 mM) leads a reduction in germination (Haddioui and Baaziz, 2006). This result indicate that salinity have a differential effect on the different stages of development of *Atriplex halimus* and those growing plants is more tolerant of salt stress than germination seeds. Similar results were previously reported for other halophytes species. (Ungar, 1982; Khan and Ungar, 1984) have indicated that salinity tolerance for growing plants is greater than at the germination stage.

CONCLUSIONS

Present results indicated that the four salts assayed (NaCl, KCl, Na_2SO_4 and K_2SO_4) caused a different effect on plant growth of *Atriplex halimus*. In general, K^+ salts were more inhibitory to growth parameters than isotonic concentrations of Na^+ salts.

This study also shows that plants grown in the high-salt treatment (300 and 450 mM) had a significant reduction in growth parameters. However, with low salinity treatments (150 mM), a little inhibition was observed.

In another hand, this study showed that salinity tolerance for growing plants differ significantly between Moroccan populations of *Atriplex halimus*. In general, the population SB (littoral provenance) is more tolerant to NaCl stress when compared to other populations. However, the inhibitory effect was stronger for population SE (continental provenance). This result will serve as an important basis for future investigations designed to selection for salt tolerance in *Atriplex halimus*.

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