Physiological and Biochemical behaviour of *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) under salinity stress

Amir Brinis¹ & Moulay Belkhodja²

¹Plant Breeding laboratory, Biology Sciences Department, Badji Mokhtar University, Annaba, Algeria
²Ecophysiology laboratory, Essenia University, Oran, Algeria

**ABSTRACT**

The halophytic species *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) was submitted to increasing levels of salinity stress (NaCl) in order to understand and quantify as well some physiological and biochemical responses. The results that have been obtained showed that plant biomass production was a function of salinity gradient. As far as chlorophyll content was concerned, decreasing content was observed for chlorophyll (a) and chlorophyll (b). The energetic potential elaborated by the species was inversely proportional to salt concentration. The accumulation of osmotic substances such as proline, soluble sugars and total proteins content increased as salinity level was increasing. These results show how important is to verify specific adaptative mechanisms to salt stress. In fact, in the present study, it is worth to emphasize how osmoregulation constitutes a reliable and interesting strategy for the species to withstand salt stress. Such an analysis may also be used in plant selection at early stage as predictive indirect tests to evaluate the possible integration of plant breeding programs.

**KEY WORDS**

Adaptation; *Atriplex canescens*; halophyte; osmoregulation; physiology; salinity.

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**INTRODUCTION**

Salinisation is defined as an enrichment of the upper surface of the soil by soluble salts. Salinisation of the soils and water is one of the major abiotic factors that limit plant productivity and agronomic yield (Zid & Grignon, 1991). In arid and semi-arid ecosystems, it results from high evaporations of water from the soil (Munns et al., 2005) and from irregular rainfall (Mezni et al., 2002). According to Ben Naceur et al. (2001), unfair irrigation is the cause of salinity. In Algeria, almost 3.2 millions hectares are threatened by salinity (Belkhodja & Bidai, 2004). Plants respond to environmental constraints by numerous changes and reveal the multifactorial character of tolerance and adaptative mechanisms of abiotic stress. The response to salt by plant species depends on the species itself, the variety, salt concentration and developing stage of plant (Ben Naceur et al., 2001). Under severe stress, plants react by several mechanisms; physiological and biochemical ones are those which are often implicated in enzymatic activity (Stephanopoulos, 1999). Synthesis of organic compounds actig as osmoprotectors or osmotic regulators is among the very well known strategy (Ratinasabapathi et al., 2000). Meas & Nieman (1975) and Shannon (1984) have identified criteria of salt tolerance, as far as
Steppic Development) were grown in pots under semi-controlled conditions.

Experiment Design: four treatments were used:
- T0: Control (without salinity)
- T1: NaCl 50 meq
- T2: NaCl 150 meq
- T3: NaCl 200 meq

The size of the pots was 20 cm width and 18 cm depth. Soil composition was a mixture of organic matter and sand in the following proportions; 2/3: 1/3.

Plantules that have been transferred in pots received 250 ml each, which correspond to field capacity. Seedlings were exposed to salt stress for four (4) weeks; observations were then recorded and physiological analysis were run.

Analysis

Biomass: it was quantified in weight of fresh and dry matter. Entire plant, shoot and root were weighted. Dry matter was obtained after 24 hours at 85°C in a laboratory oven.

Chlorophyll content: it was performed according to McKinney & Arnon (1949).

Prolin content: the analysis was run according to Monneveux & Nemmar (1986).

Soluble sugars content: according to Shields & Burnett (1960).

Statistical analysis: according to Dunnett (1964)

RESULTS AND DISCUSSION

Effect of salinity according to Dunnett test

As far as results are concerned (Fig. 1), it appears that plants respond positively to salt gradient. Most favorable levels seem to be T1 and T2. In a general manner, except for root biomass which remains stable, Atriplex L. show its ability of halophytic species. This positive responses obtained in T1 and T2 could have been a result of biochemical mechanism that increased Fresh Matter yield. The salinity level T1 and T2 could have been also considered as sort of mineral nutrient for seedlings. Beyond these levels, salinity become harmful eventough Atriplex seems to sustain salt concentrations.

As shown in Figure 2, dry matter weight is similar to fresh weight, as far as salinity levels are con-
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Figure 1. Fresh matter weight in *Atriplex canescens* according to salinity levels.

Figure 2. Dry matter weight in *Atriplex canescens* according to salinity levels.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total Fresh Matter</th>
<th>Shoot Fresh Matter</th>
<th>Root Fresh Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>probability</td>
<td>mean</td>
</tr>
<tr>
<td>T0</td>
<td>5.90</td>
<td>0.104</td>
<td>4.000</td>
</tr>
<tr>
<td>T1</td>
<td>10.400</td>
<td>Non</td>
<td>8.200</td>
</tr>
<tr>
<td>T2</td>
<td>10.700</td>
<td>Significant</td>
<td>8.150</td>
</tr>
<tr>
<td>T3</td>
<td>7.650</td>
<td>Significant</td>
<td>5.250</td>
</tr>
</tbody>
</table>

Table 1. Fresh matter weight analysed by Dunett test.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total Dry Matter</th>
<th>Shoot Dry Matter</th>
<th>Root Dry Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>probability</td>
<td>mean</td>
</tr>
<tr>
<td>T0</td>
<td>2.218</td>
<td>0.468</td>
<td>1.641</td>
</tr>
<tr>
<td>T1</td>
<td>2.723</td>
<td>Non</td>
<td>1.942</td>
</tr>
<tr>
<td>T2</td>
<td>2.486</td>
<td>Significant</td>
<td>1.676</td>
</tr>
<tr>
<td>T3</td>
<td>2.217</td>
<td>Significant</td>
<td>1.145</td>
</tr>
</tbody>
</table>

Table 2. Dry matter weight analysed by Dunett test.
Figure 3. Chlorophyll content in *Atriplex canescens* according to a salinity gradient.

Figure 4. Proline accumulation in *Atriplex canescens* according to a salinity gradient.

Figure 5. Total proteins accumulation in *Atriplex canescens* according to salinity levels.

Figure 6. Soluble sugars accumulation in *Atriplex canescens* according to salinity levels.

<table>
<thead>
<tr>
<th>Chlorophyll (a)</th>
<th>Chlorophyll (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Probability</td>
</tr>
<tr>
<td><strong>T₀</strong></td>
<td>16.27</td>
</tr>
<tr>
<td><strong>T₁</strong></td>
<td>12.02</td>
</tr>
<tr>
<td><strong>T₂</strong></td>
<td>2.06</td>
</tr>
<tr>
<td><strong>T₃</strong></td>
<td>7.69</td>
</tr>
</tbody>
</table>

Table 3. Chlorophyll content analysed by Dunett test.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T₀</strong></td>
<td>16.15</td>
<td>0.000***</td>
</tr>
<tr>
<td><strong>T₁</strong></td>
<td>38.5</td>
<td>Very highly</td>
</tr>
<tr>
<td><strong>T₂</strong></td>
<td>42.82</td>
<td>Significant</td>
</tr>
<tr>
<td><strong>T₃</strong></td>
<td>32.85</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Proline accumulation analysed by Dunnet test.
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### CONCLUSIONS

Numerous physiological mechanisms and biochemical ones are regarded as being adaptive responses to salt and constitute specific adaptive traits.

Thus, each response is translated by physiological or biochemical marker. *Atriplex* constitute an interesting model for quantitative evaluation of different yield traits. Because of it’s ability to maintain soil and preserve it against erosion that may occur under drastic environmental conditions, drought in particular, *Atriplex* may play a very important role in sustainable development areas. As to whether or not salt is to be considered one of the main abiotic constraints, much has to be done and emphasized on getting new tools of adaptive strategies. *Atriplex* is among those suitable solutions because of its capacity of covering soils, preventing them from erosion and constituting a substantial nutritional value as well, for sheep mainly.

On the basis of these indirect tests, which are physiological and biochemical ones, it appears that some of them can be of great reliable interest. The exploration of how the species behave to face to salt...
stress, helps us in selecting determinant traits worth to be incorporated in breeding programs.

REFERENCES


