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

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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 breeing 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 (Stephanopoulus, 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 grain yield, seed vigor, foliaire damage and height of plants were concerned.

Many other approaches, such as anatomic, ecological, physiological and molecular ones, were used in order to understand to what extend these modifications may reduce harmfull effects of salt stress (Poljakoff-Mayber, 1988). As we consider salt tolerance mechanisms, according to Piri et al. (1994) resistance of plants is expressed by the capacity to survive and reproduce in presence of salt stress conditions. In plants that are sensitive to NaCl, Na+ cation is accumulated in the leaves. This kind of types are called "excluders", as compared to tolerant ones to NaCl that are called "includers". in this last types, leaves are less Na+ concentrate than roots (Haouala et al., 2007). According to Hadjadj (2009), soluble sugars accumulation in leaves is important under salt stress. In numerous species more or less resistant, it was observed an increase of total sugars (Asloum, 1990), resulting of non occuring glycolysis. Osmoregulation is one of the main adaptative strategies in response to abiotic stress, particulary salinity and drought (Benhassaine et al., 2010). Rezkallah et al. (2014) showed that accumulation of NaCl had an effect on physico-chemical characteristics of the soil. Al Satari (2014) demonstrated that an efficient use of arid soils may occurr by growing several species in the same area thus having a better valorisation of these soils. On the other hand, the choice of the species to be grown in arid and semi-arid zones is determined, according to Falasca et al. (2014) by several factors, among which temperature, rainfall, type of the soil and water availability for irrigation. In salt soils, some species are threatened by extinction (Chamard, 1993); others show adaptative mechanisms (Hare & Cress, 1997). In fact, in these environments, plants adjust osmotically (Godghirs et al., 1990) their cell content by synthetizing amino acids, such as prolin (Ashraf & Mc Neily, 2004).

MATERIAL AND METHODS

Plant material

Seedling plants of *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) issued from the nursery of H.D.S.D. (High District of 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 Mc Kinney & 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 Dunett 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-

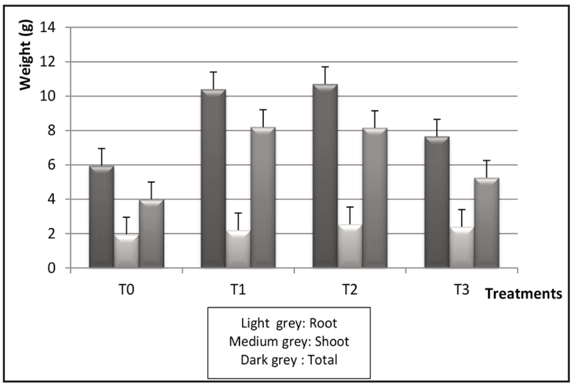

Figure 1. Fresh matter weight in *Atriplex canescens* according to salinity levels.

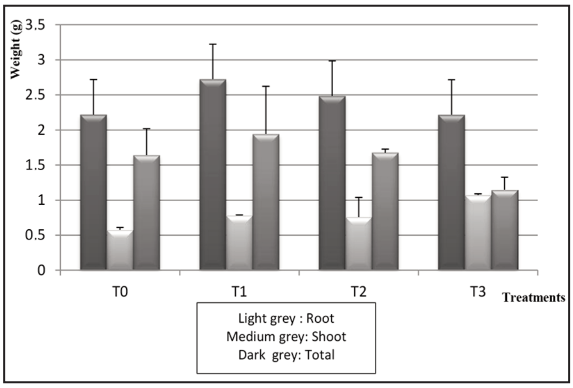

Figure 2. Dry matter weight in *Atriplex canescens* according to salinity levels.

	Total Fresh Matter		Shoot Fresh Matter		Root Fresh Matter	
	mean	probability	mean	probability	mean	probability
T_0	5.90	0.104	4.000	0.098	1.950	0.149
T_1	10.400		8.200		2.200	
T_2	10.700	Non	8.150	Non	2.550	Non
T_3	7.650	Significant	5.250	Significant	2.400	Significant

Table 1. Fresh matter weight analysed by Dunett test.

	Total Dry Matter		Shoot Dry Matter		Root Dry Matter	
	mean	probability	mean	mean	probability	mean mean
T_0	2.218	0.468	1.641	0.184	0.576	
T_1	2.723		1.942		0.783	0.017*
T_2	2.486	Non	1.676	Non	0.759	Significant
T_3	2.217	Significant	1.145	Significant	0.070	

Table 2. Dry matter weight analysed by Dunett test.

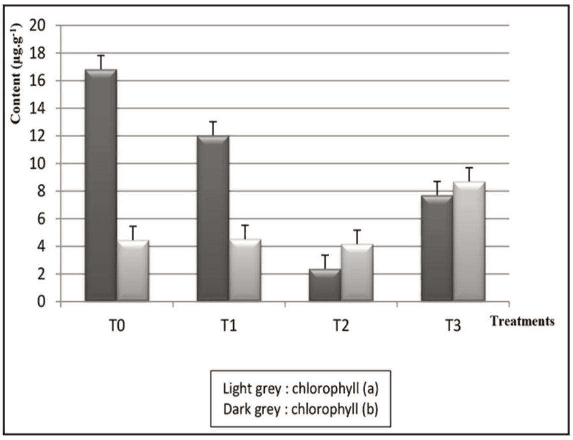

Figure 3. Chlorophyll content in *Atriplex canescens* according to a salinity gradient.

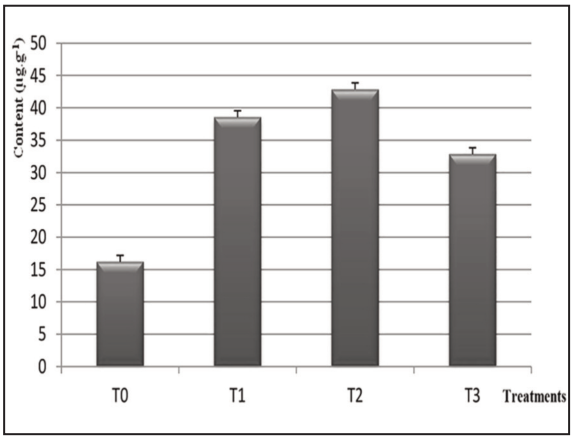

Figure 4. Proline accumulation in *Atriplex canescens* according to a salinity gradient.

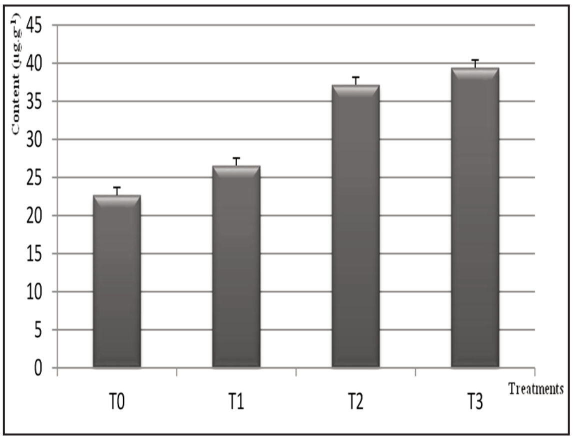

Figure 5. Total proteins accumulation in *Atriplex canescens* according to salinity levels.

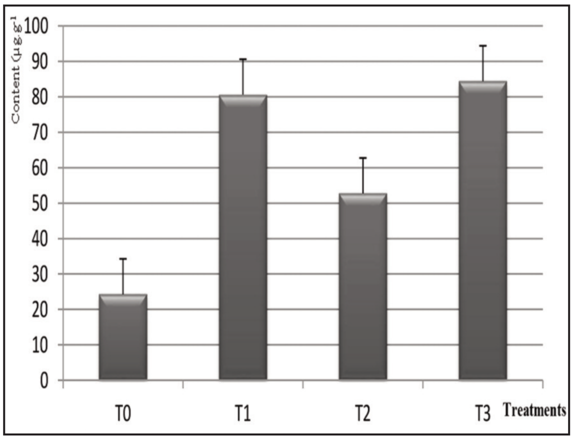

Figure 6. Soluble sugars accumulation in *Atriplex canescens* according to a salinity levels.

	Chlorophyll (a)		Chlorophyll (b)	
	Mean	Probability	Mean	Probability
T_0	16.27	0.003** Highly Significant	4.44	0.002** Highly Significant
T_1	12.02		4.51	
T_2	2.06		4.11	
T_3	7.69		8.69	

Table 3. Chlorophyll content analysed by Dunett test.

	Mean	Probability
T_0	16.15	0.000*** Very highly Significant
T_1	38.5	
T_2	42.82	
T_3	32.85	

Table 4. Proline accumulation analysed by Dunnet test.

	Mean	Probability
T_0	22.68	0.000*** Very highly Significant
T_1	26.56	
T_2	37.16	
T_3	39.4	

Table 5. Total Proteins accumulation analysed by Dunett test.

	Mean	Probability
T_0	24.3	0.025*
T_1	80.69	
T_2	52.84	
T_3	84.53	

Table 6. Soluble Sugars accumulation analysed by Dunnett test.

cerned. Treatments T1 and T2 had accumulated more biomass for shoot. As far as roots are concerned, salinity did not show important incidence for biomass yield (dry matter).

Chlorophyll content

A decrease in chlorophyll content was observed except for T3 (Fig. 3). This helps us to understand that *A. canescens* uses other adaptative mechanisms to salt stress.

Table 3 shows That different treatments had high significant difference for chlorophyll (a); (0.003**) and chlorophyll (b); (0.002**).

Osmoprotectors - Proline accumulation

In figure 4, when salinity stress is increased, proline accumulation increased too. Because of this increase, *A. canescens* proved to behave as halophytic species. Satistical analysis shows very high significant differences between treatments. This might be due to endogenic ability of *A. canescens* to sustain high salinity level (T3).

Selection of tolerant cultivars could be based on such performance; as far as osmoregulation is concerned.

Total proteins

High NaCl concentrations stimulated protein accumulation. Very high significant differences are obtained using Dunett test (Table 5).

Soluble Sugars

Except for treatment T2 (Fig. 6) High NaCl concentration has caused soluble sugar accumulation. Dunnett test show significant differences between treatments.

CONCLUSIONS

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

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