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Adaptive responses to high salinity of two subspecies of *Aster tripolium* on different nitrogen sources

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ABSTRACT The effects of NaCl salinity, different N-sources (nitrate or ammonium), as well as pH on the major enzymes of N-metabolism and total antioxidant capacity were investigated in two subspecies of *Aster tripolium* L., *A. tripolium* ssp. tripolium, a maritime halophyte, and *A. tripolium* ssp. pannonicus, endemic on the continental alkaline salty meadows. Differences in their biochemical and physiological responses to the experimental conditions are in agreement with their evolutional adaptation either to the fluctuating coastal circumstances or to the more constant salinity level on the alkaline salty meadows. Accordingly, *A. tripolium* ssp. tripolium reacted more sensitively to salinity while *A. tripolium* ssp. pannonicus showed less physiological flexibility and more stable performance. **Acta Biol Szeged 49(1-2):115-116 (2005)**

KEY WORDS

A. tripolium ssp. tripolium
A. tripolium ssp. pannonicus
glutamine synthetase
nitrate reductase
N-sources (nitrate, ammonium)
total antioxidant capacity

Soil salinity is an important agricultural problem. One possible way to use affected fields is planting salt tolerant crops such as *Aster tripolium* L..

Aster tripolium (Asteraceae/Compositae) is a typical halophyte species with two horizontally isolated subspecies (Borhidi 1995). The two subspecies are very different concerning their habitats, morphology and physiology. The ssp. tripolium is a maritime halophyte, while ssp. pannonicus is common on the continental alkaline salty meadows. Morphological differences are obvious in leaf size and shape, leaf colour, leaf number and growth habitus. Both ssp. accumulate inorganic ions even at low external concentrations. Physiologically sea aster was more intensively studied (Shennan et al. 1987ab) because of its recently increasing commercial importance as halophyte crop. Its value is the mild salty taste and high protein content of the succulent leaves. The ssp. pannonicus inhabits salty meadows rich in $NaHCO_3$ thus having high pH.

Materials and Methods

Two subspecies of *Aster tripolium* were examined in our experiments: ssp. tripolium and ssp. pannonicus. Plants were grown hydroponically in complete modified Hoagland nutrient solution of different pH values (from 4 to 10). In one container, 7 plants of each of the subspecies were placed and were grown for 6 weeks under controlled conditions in greenhouse at an additional light intensity of 100 μmol m^{-2} s^{-1} for 12 hours. Day/night temperature was 24/18ºC. The pH values were controlled and adjusted daily by addition of HCl or NaOH. On the basis of protein content data (Bradford 1976), pH 5 and 8 were selected for further experiments when plants were grown at 0, 50, 100, 200 and 300 mM NaCl concentrations added to the complete nutrient solution. The nutrient solutions also altered in there nitrogen source which was nitrate or ammonium, respectively. Chlorophyll (Lichtenthaler 1987), protein content, cation concentrations, nitrate reductase (Mauriño et al. 1986), glutamine synthetase (Rhodes et al. 1975) activity and total antioxidant capacity with FRAP method (Benzie and Strain 1996) were measured in both leaves and roots. Cation concentrations were determined by atomic absorption spectrophotometry (Hitachi, Type Z-8200).

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Results and Discussion

Aster tripolium ssp. tripolium obviously suffered under low salt conditions combined with high pH values as shown by the low pigment concentrations. In both subspecies, qualitative and quantitative alterations were observed in protein concentrations with increasing salinity and pH values. At low pH and medium salt concentrations, ssp. tripolium had higher protein levels than ssp. pannonicus, while at high pH values ssp. pannonicus had higher performance. Very high Na^+ concentrations were accumulated in the leaves in both pH regions. Calcium is known to play a special role in tolerance under salinity. Surprisingly, in ssp. pannonicus Ca^{2+} accumulation increased under the highest NaCl concentrations (300 mM) while in contrast, ssp. tripolium showed a decreasing tendency in calcium accumulation under increasing external salinity.

In the following pH 5 was selected and the nitrogen source was nitrate or ammonium, respectively. Our intention was to investigate enzymes involved in nitrogen metabolism as a function of sodium concentration. Nitrate reductase (NR), glutamine synthetase (GS) activity and total antioxidant capacity were measured in both leaves and roots. Control (0), 10, 50, 100 and 200 mM NaCl was added to the nutrient solutions with both nitrogen sources. One of our interesting results was that young leaves of *Aster tripolium* ssp. tripolium

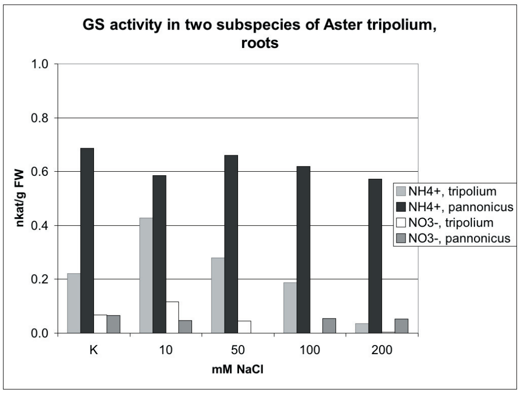

Figure 1. Effects of salinity and N-source in the nutrient solution on glutamine synthetase activity in roots of *Aster tripolium* ssp. tripolium and *A. t.* ssp. pannonicus.

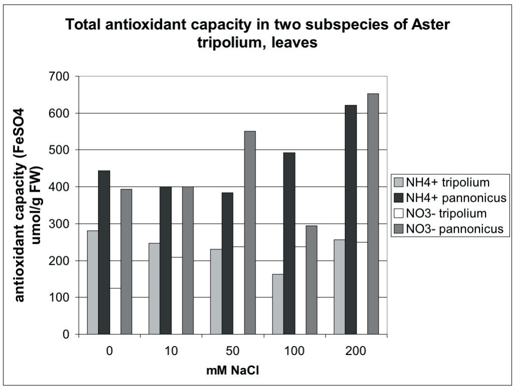

Figure 2. Effects of salinity and N-source in the nutrient solution on nitrate reductase activity in the leaves of *Aster tripolium* ssp. tripolium and *A .t.* ssp. pannonicus.

treated with ammonium and relatively low NaCl concentrations became chlorotic, while on high salt concentrations showed the signs of ammonium toxicity. Toxicity symptoms: roots turn brown and appear unhealthy, with necrotic root tips; plant growth is decreased; necrotic lesions occur on stems and leaves. Ammonium toxicity is common in soilless, highly acidic media.

In plants, grown on solution containing ammonium, in the root of both subspecies, GS activity was higher in control plants (especially in ssp.pannonicus) than in plants grown on nitrate. In the case of ssp. tripolium GS activity had an optimum as a function of Na^+ concentration while in ssp. pannonicus the activity remained steadily high (Fig. 1). In the leaf, increasing GS activity was observed. When the nitrogen source is nitrate we can say that the scene of nitrate processing is not in the root: GS activity is about threefold higher in leaves than in roots, and much lower than in the roots of plants grown on ammonium. It seems that ammonium uptake is enhanced by NaCl. NR activity in the root decreased with increasing Na^+ concentrations when getting ammonium and did not change characteristically on nitrate. In leaves of plants grown on NH_4^+ the activity remained low in both subspecies but it was two-threefold higher on NO_3^- nutrition and the activity increased with increasing sodium concentrations (Fig. 2). The total antioxidant capacity was more a question of subspecies than nitrogen source: in ssp. pannonicus it was 150-200% higher then in ssp. tripolium, and it was increasing at high exogenous sodium concentrations (Fig. 3). In the case of ssp. tripolium there were not so characteristic changes.

We conclude that *Aster tripolium* ssp. tripolium reacts more sensitively to the different conditions while ssp. pannonicus have steadier performance, which can be regarded as adaptive responses to their environmental conditions.

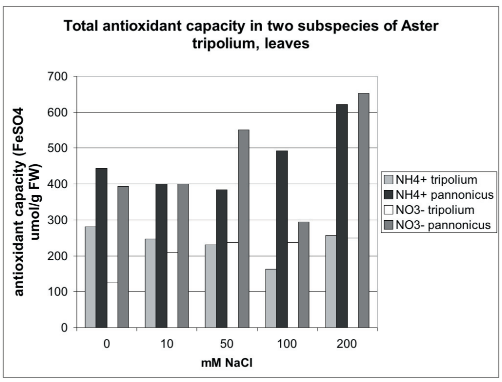

Figure 3. Effects of salinity and N-source in the nutrient solution on the total antioxidant capacity int he leaves of *Aster tripolium* ssp. tripolium and *A. t* . ssp. pannonicus.

Acknowledgements

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