

Evaluation of a potential candidate for heavy metal phytostabilization in polluted sites of the Mediterranean littoral (SE Marseille): endomycorrhizal status, fitness biomarkers and metal content of *Atriplex halimus* spontaneous populations

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Summary. This study showed that *Atriplex halimus* forms endomycorrhizae on heavy metal polluted-soils. But no variation of chlorophylls content in leaves was observed. Only low concentrations of heavy metals were found in leaves compared with the high levels of pollutants in the soil. *A. halimus* appears as a good candidate for phytostabilization of heavy metals in brackish soils.

Key words: Mediterranean saltbush, endosymbionts, heavy metal, phytoremediation.

1. Introduction

Atriplex halimus L., originated from North Africa, is a widespread Mediterranean shrub species (Ortíz-Dorda et al. 2005) with high resistance to various abiotic stresses included heavy metals (HM) (Lutts et al. 2004; Lefèvre et al. 2009). However, since this species shows a high genetic variability (Ortíz-Dorda et al. 2005), phytoextraction capacities may greatly vary from one population to another. Moreover, biotic parameters may also modify the phytoremediation potential of this species. Although Chenopodiaceae family is normally defined as non-mycorrhizal, more than 10 species of *Atriplex* genus were found to form endomycorrhizal associations (Sonjak et al. 2009). However, there

is no report about the arbuscular mycorrhizal (AM) status of *A. halimus*. This study aimed to determine the occurrence of AM associations, HM, chlorophylls and flavonols contents of leaves of *A. halimus* in polluted soils and to define whether or not *A. halimus* is a good candidate for phytoremediation.

2. The study area

Spontaneous populations of *A. halimus* from three sites named Calanque de Saména, Calanque du Trou, and Cap Croisette were selected at the vicinity of the former industrial site of l'Escalette (Marseille, S–E France).

3. Research methods

Root sampling was done on five individuals in each population. The percentage of mycorrhizal root length was estimated by visual observation of fungal colonisation after clearing washed roots in 10% KOH and staining with lactophenol blue solution, according to Phillips and Hayman (1970). Fitness biomarkers were monitored using a non-destructive Multiplex® equipment that uses fluorescence technology with multiple excitations to measure chlorophylls and flavonols including anthocyanins. By individual, 15 measurements were done on 5 plants by population. On leaves and soil samples, Cd, Cu, Fe, Pb, and Zn were analysed by ICP-AES, As was analysed by graphite furnace AAS and by flame AES were analysed Na and K. Transversal leaf sections were carbon metallized for observation under an ESEM Philips XL 30 microscope. The EDXS spectra for the compositional analyses and X-ray mapping were performed on the samples.

4. Results and discussion

In two out of the three sites, representative mycelia and vesicles were observed in the roots of all individuals. No variation of chlorophylls content in leaves was observed between the sites. Lower levels of anthocyanins and total flavonols were observed in Cap Croisette individuals. Only low concentrations of HM were found in leaves compared with the high levels of pollutants in the soil. All stations appeared polluted from the industrial source. SEM coupled with elemental analysis did not enable to localise specific HM deposition in the leaf tissues. However, accumulation of Na, K and Cl was revealed by this method in leaf glands relative to the salt accumulation ability of the species. As for Na and Cl, the presence of highly detectable level of Mg and S is related to their abundance in seawater. To our knowledge it is the first SEM evidence of Mg and S localization in salt glands. Considering the low trace-element translocation in the aerial parts, *A. halimus* appears as a good candidate for phytostabilization of HM in brackish soils of the Mediterranean coast. Previous studies of antagonism of metal versus salt on *Atriplex* genus focused on root absorption (Lefèvre et al. 2009) or adsorption of dead tissues (Sawalha et al. 2009). Our observations showed that leaf absorption of all the elements present in

seaspray might also play a role in metal tolerance of *Atriplex halimus* submitted to metal polluted soils on the seashore. However as an alien species in France, its invasive potential has to be determined before a large scale-use.

Acknowledgements

The authors thank Soumia Djilalli, Cécile Evrard and Thomas Devenoges for their technical assistance of root preparation, Laurent Vassalo and Carine Demelas for their analytical assistance for HM measurements and the ANR for the Marséco program grant (2008 CESA 018).

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