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Ecological role of bracteoles in seed dispersal and germination of the North African halophyte *Atriplex mollis* under contrasting environments

Abderrazak Tlili[a], Jamila Zammouri[a], Mustapha Gorai[b] and Mohamed Neffati[a]

[a]Arid Land Institute, Laboratory of Pastoral Ecosystems and Valorization of Spontaneous Plants and Associated Microorganisms, University of Gabes, Medenine, Tunisia; [b]Higher Institute of Applied Biology of Medenine, University of Gabes, Medenine, Tunisia

ABSTRACT

The patterns of germination responses of *Atriplex mollis* seeds reveal species-specific tolerances and represents the adaptive strategies of species to stressful environments. To the best of our knowledge, this is the first report about germination patterns of *A. mollis* providing basic information for its conservation and reintroduction into degraded lands. Herein, two seed lots, with and without bracteoles, were tested for germination (i.e. salinity and drought). The highest germination percentage was under non-saline conditions, and with increasing NaCl-salinity, seed germination is inhibited. Bracteoles did not affect germination at low salinity levels, but significant inhibition becomes evident at −0.75 MPa. Moreover, PEG-induced osmotic stress had an adverse effect on germination of seeds with or without bracteoles at −0.75 MPa (ca. 20% and 10%, respectively). Bracteoles have a significant decreased effect on germination during recovery; they showed more detrimental effects following NaCl than PEG incubation. Importantly, the flotation of dispersal units with bracteoles was less than 60% under in freshwater and reached 100% at 27 g NaCl L^{-1}. It is concluded that bracteoles play a dual role by inhibiting germination under high salinity levels and enhancing it under less negative osmotic potential.

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Introduction

Salinity, drought and temperature are the main abiotic factors that often decrease the establishment of plants in arid and semi-arid regions, especially those that have been degraded by human activities (Zhang, Wu, and Tang 2016a). The management and restoration of arid areas should be based on a good knowledge of the physiological attributes of extremophile plants (xerophytes and halophytes). Among the extremophile species, the halophyte *Atriplex mollis* Desf. (Amaranthaceae) is considered to be an appropriate plant candidate for restoration. It can tolerate high salinity levels by excreting salts via vesicular hairs (Pottier-Alapetite 1979), and it grows best in soils where NaCl levels are around 20 g L^{-1}. It is endemic to North Africa and is distributed from southern Tunisia and to Algeria and Libya (Pottier-Alapetite 1979; Greuter, Burdet, and Long 1984; Tlili et al. 2019). In Tunisia, the species grows in small populations in the upper border of coastal salt marshes (chott and sebkhas) (Tlili, personal observation). This shrubby species is mainly used as forage for livestock and to rehabilitate degraded and salt-affected soils. It is a monoecious perennial C3 shrub, up to 50 cm high and with many branches from the base. The mean fruit production of 18-month-old plants of *A. mollis* was estimated at 113 ± 29 g $plant^{-1}$ (Tlili et al. 2019), and the mass of 1000 seeds was 2.22 ± 0.11 g (mean ± SD, n = 3). Until now, there has been little experimental research with *A. mollis*, but knowledge about its seed germination requirements is very important in characterizing this halophytic shrubby species ecologically.

The dispersal unit of *Atriplex* is a one-seeded fruit (Pottier-Alapetite 1979) surrounded by two bracteoles of different sizes that vary in degree of attachment to the pericarp. Bracteoles play an important role in seed germination behavior and may be essential for dispersal of the fruits (Mandák and Pyšek 2001; Ungar and Khan 2001; Muñoz-Rodríguez et al. 2012). Previous work on seed germination of *Atriplex* species has focused on the effects of bracteoles and their ecological roles. It was shown (Muñoz-Rodríguez et al. 2012) that bracteoles of *A. halimus* (L.) played an important role in inhibiting germination when dispersal units were exposed to 0.3 M NaCl, only allowing germination in freshwater. Inhibition or delay of germination due to bracteoles has been reported for *A. griffithii* Moq. (Ungar and Khan 2001), *A. nummularia* Lindl., *A. vesicaria* Heward., *A. semibaccata* R.Br., *A. inflata* F.Muell., *A. spongiosa* F.Muell. (Beadle 1952) and *A. sagittata* Borkh. (Mandák and Pyšek 2001). Unlike previous works, Zhang et al. (2016b) showed that bracteoles of

CONTACT Abderrazak Tlili tlili_abderrazak@yahoo.fr Arid Land Institute, Laboratory of Pastoral Ecosystems and Valorization of Spontaneous Plants and Associated Microorganisms, University of Gabes, Medenine 4100, Tunisia

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