Salt Secretion Is Essential for Xero-Halophyte *Reaumuria soongorica* Responding to Osmotic Stress

Ai-Ke Bao
Lanzhou University, China

Hang-Yu Zhou
Lanzhou University, China

Suomin Wang
Lanzhou University, China

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Salt secretion is essential for xero-halophyte *Reaumuria soongorica* responding to osmotic stress

Bao Ai-Ke, Zhou Hang-Yu and Wang Suo-Min

State Key Laboratory of Grassland Agro-ecosystems, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou 730020, People's Republic of China

Contact email: baoaik@lzu.edu.cn

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Introduction

Reaumuria soongorica, a xero-halophyte semi-shrub belonging to Tamaricaceae with excellent adaptability to adverse arid and salinity environments of northwest China, serves important ecological roles in the improvement of saline-alkali soil and dune stabilisation, and also is an attractive fodder shrub in desert steppe (Ma *et al*. 2011). Previous studies demonstrated that secreting salt via salt glands is an important strategy for *R. soongorica* adapting to high salinity environments (Zhou *et al.* 2012). However, very little is known about the role of salt secretion in the plant's responses to drought. Therefore, in the present work, *R. soongorica* seedlings were subjected to osmotic stress in the presence or absence of additional NaCl to determine the potential relationship between salt secretion and drought tolerance of *R. soongorica* seedlings.

Methods

Plant material and treatments

The *R. soongorica* seedlings were cultured in sand irrigated with modified 1/2 strength Hoagland nutrient solution. Six-week-old seedlings were divided into 3 groups: control (C), osmotic stress (D) and osmotic stress with additional salt (D+S). Plants of C group continued to be irrigated with the same nutrient solution during the experimental period. In the two treatment groups, plants were cultured with the same nutrient solution supplemented without (D) or with 50 mM NaCl (D+S) for 4 days, then were exposed to -0.5 MPa osmotic potential induced by sorbitol for 3 days.

Physiological assays

Salt secretions and cation concentrations were determined as described by Wang *et al.* (2009). The shoot osmotic potential (Ψs) and contributions of cations to Ψs were assayed as mentioned by Ma *et al.* (2012).

Results

Fresh weight and tissue water content of R. soongorica

In comparison with the control, shoot fresh weight (SFW) was significantly reduced by 25% when plants were subjected to osmotic stress (-0.5 MPa); however, a significant increase in SFW by 32% was observed in plants grown in the presence compared with the absence of additional 50 mM NaCl under osmotic stress (Fig. 1A), suggesting the addition of 50 mM NaCl alleviated the deleterious impact of osmotic stress on growth of *R. soongorica*. Moreover, the tissue water contents showed no significant difference between the control and plants from osmotic stress treatments (Figure. 1B).

The Na^+, K^+ secretion from R. soongorica

Only a small amount of salt crystallization was observed on leaf surfaces of control plants (Fig. 2A); however, osmotic stress significantly enhanced the amounts of salt crystallization, which showed an even greater increase in the presence of osmotic stress with additional 50 mM NaCl. Further analysis showed that osmotic stress triggered a significant increase in secretion of Na^+ but not K^+ (Fig. 2B), suggesting osmotic stress could induce Na^+ secretion of *R. soongorica*.

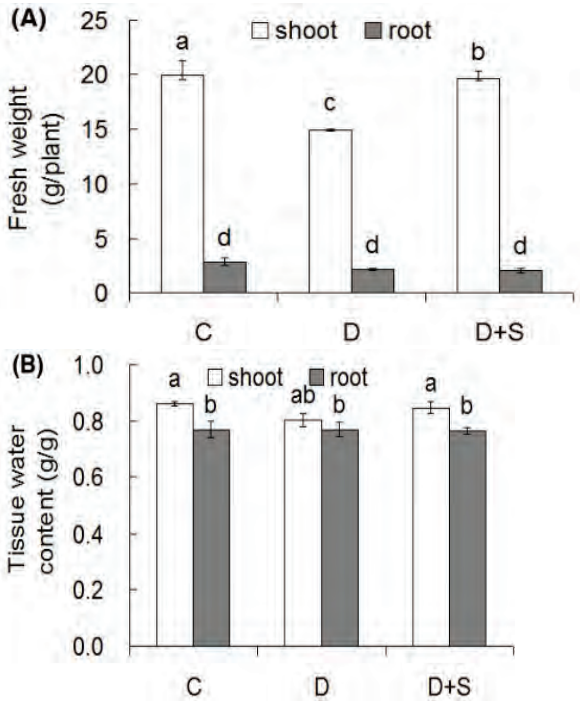

Figure 1. Fresh weight and tissue water content of *R. soongorica* seedlings. C, control; D, -0.5 MPa osmotic stress; D+S, -0.5 MPa osmotic stress with 50 mM NaCl) for 3 days.

Table 1. Shoot osmotic potential (Ψs), Na^+ and K^+ concentrations, and the contributions of Na^+ and K^+ to osmotic potential (Ψs) of *R. soongorica* seedlings. C, control; D, -0.5 MPa osmotic stress; D+S, -0.5 MPa osmotic stress with 50 mM NaCl) for 3 days.

Treatments	Ψs (MPa)	Na^+ concentration (mmol/g DW)	K^+ concentration (mmol/g DW)	Contribution of Na^+ to Ψs (%)	Contribution of K^+ to Ψs (%)
C	-2.3±0.03 c	0.75±0.03 b	0.99±0.08 a	13.0±0.5 a	7.1±0.2 a
D	-3.6±0.10 b	0.82±0.05 b	0.89±0.04 a	13.6±1.1 a	6.5±1.0 a
D+S	-4.0±0.07 a	1.09±0.11 a	0.84±0.10 a	11.7±0.4 b	3.8±0.3 b

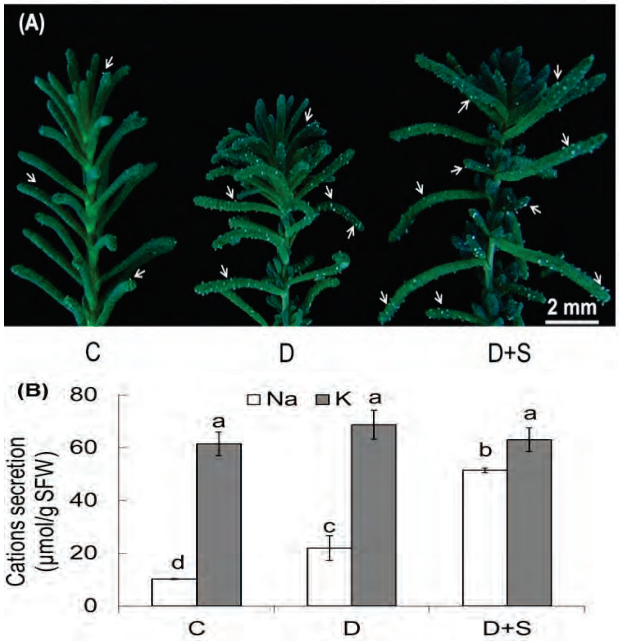

Figure 2. Salt crystallization on leaf surface (A) and amount of Na^+, K^+ secretion (B) of *R. soongorica* seedlings. C, control; D, -0.5 MPa osmotic stress; D+S, -0.5 MPa osmotic stress with 50 mM NaCl) for 3 days.

Shoot Na^+ and K^+ accumulation and their contributeion to osmotic potential (Ψs) of R. soongorica

Compared with the control, shoot Na^+ concentration was unchanged under osmotic stress, and only slightly increased in the presence of an additional 50 mM NaCl and osmotic stress. On the other hand, shoot K^+ concentration was unaffected by either osmotic stress or the addition of 50 mM NaCl and osmotic stress (Table 1). Further investigations indicated that osmotic stress decreased shoot Ψs, whether with or without additional 50 mM NaCl. It is interesting that the contribution of either Na^+ or K^+ to total osmotic potential showed no significant difference between the control and plants that suffered osmotic stress, and even decreased in the presence of additional 50 mM NaCl and osmotic stress (Table 1). Combined with the data from Figure 1A, these results imply that secreting more Na^+ may contribute to maintaining the water balance of *R. soongorica* under osmotic stress.

Conclusion

Our results demonstrated that 50 mM NaCl enhanced the osmotic tolerance of *R. soongorica*. This should be ascribed to the ability of *R. soongorica* to secrete more Na^+, which might contribute to maintaining the water balance and stability of shoot K^+ concentration under osmotic stress. Therefore, it can be concluded that salt secretion plays important roles in xero-halophyte *R. soongorica* responding to osmotic stress.

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